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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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A Practical Foundry Educational Scheme.

In our last issue we pointed out that the Board of Education Report on Foundry Education fell short in two outstanding features. The first was the poorness of the constructive suggestions for its amelioration, and the second the almost complete disregard for the economic aspect. Further, we suggested that an intensive metallurgical training should be the object sought in the training of foundry workers. It is thus a matter of much satisfaction to us that the educational authorities of Sheffield, headed by its University, in conjunction with the foundry owners, and representatives from the local branch of the Institute of British Foundrymen, the Sheffield Foundry Trades' Technical Society, and the trade unions concerned have devised a most satisfactory scheme, incorporating these features. The scheme is well worth copying by other large towns and with modifications by foundry districts. This scheme, which is printed elsewhere, contains all the features essential to the actual conditions in which foundry apprentices are surrounded, and it is the realisation of this which makes us sanguine of its success. Primarily, there is to be an effort on the part of the boy; without this the scheme will never turn out the best type of man. Secondly, the economic side has received recognition by the payment of a bonus for each examination passed, and a remission of the fees paid for satisfactory attendance. Thirdly, the scheme is elastic, as boys can take their first classes at Council schools situated either near their homes or the works.

It has been truly said that engineers are born and that metallurgists are made. If Sheffield converts the bulk of the moulders during the next generation into practical metallurgists, we have no doubt that the trade, both locally and nationally, will benefit. We realise that many country jobbing foundries would prefer a closer association of the moulder with the engineer rather than with the metallurgist. But that class should realise that engineering operations can be understood through their carrying out, but a special training is required for the correct interpretation of metallurgical processes, and we insist that the manufacture of castings is a metallurgical, and not an engineering, process. By the time that the apprentice has passed through the evening metallurgical classes, held in the laboratories of the Department of Applied Science of Sheffield University, he will be so keen on the acquiring of scientific knowledge that he will require no inducement to continue, because we are aware that in the past many students have continued with evening study many years after they have passed the whole of their direct professional examinations. Sheffield educational facilities have converted dozens of laboratory boys into metallurgists of the best type. Whether it can do the same for the apprentice moulder, the next ten years will reveal. There is but one factor necessary for the success of the scheme, and that is enthusiasm, which must be exhibited by all concerned.

We have received letters from time to time asking for the institution of foundry certificates of a national character. Now that the Sheffield Education Authorities have formulated such a progressive scheme, we hope it is possible to induce Sheffield University to act as a national examining body for foundry workers. As a metallurgical school, it is second to none in the world, and no one would hesitate in accepting such a certificate, as being of the highest value. We further throw out the suggestion that it might extend its degree course and grant one reading B.Met. (Foundry) just as other universities have their B.Sc. (Eng.). Such a degree would indicate that the student had concentrated on cast rather than wrought materials.

It is interesting to note from the Report that secondary school boys are now working in foundries, and we hope that this lead will be followed by other centres. They are catered for in such private schemes as that in operation at the works of the Metropolitan-Vickers concern at Trafford Park. Finally, we ask all foundries who have inaugurated apprenticeship schemes carefully to examine the Sheffield organisation, and, if possible, to work on similar lines, so that a foundry owner may visualise what he may expect from a man trained on modern lines.

Apprentice Training of the Foundry Boy.

Special Course Adopted by the University of Sheffield.

Much attention has recently been given to the subject of the education and training of the foundry apprentice, and several schemes have been adopted in various parts of the country. In some of the larger works a very thorough system of training has been adopted, and the employment of a large number of apprentices in these works enables such efficient systems to be employed.

In the Sheffield district all sections of the foundry trade have felt the need for some systematic method of training the apprentices, and conferences have been held of representatives from the employers, workmen, welfare supervisers, the Institute of British Foundrymen, the Sheffield Foundry Trade Technical Society and the Local Education Authorities. At these conferences it was pointed out that the trade is not sufficiently attractive to induce the most intelligent boys, especially at the secondary schools, to enter the foundries and to consider the foundry as offering sufficient scope for a promising career. There were also other serious difficulties which made the position of the foundry apprentice a less encouraging proposition to those about to seek a career. On the other hand, there was ample scope for first-class practical all-round men to acquire important posts on the management of the foundries, and the problem was how to improve the conditions of training so as to ensure the thorough teaching of the principles of the trade to the apprentice, and also to give him sufficient experience in the various classes of work to enable him to become a craftsman.

The problem was rendered more difficult by the modern tendency towards specialisation and the absence of any methods whereby the apprentice can obtain some knowledge of patternmaking and cupola work, in addition to moulding. It was agreed that whilst it was not necessary for a foundryman to have much experience of patternmaking, yet he should be conversant with the principles upon which this important trade was founded, and have some knowledge as to how and why the patterns were so constructed.

An All-round Craftsman.

It was also very desirable for the foundryman to have some knowledge of the preparation of the metal and the technical work in connection with the cupola if he was to become an all-round craftsman.

This work should include the study of metallurgy applied to foundry work, and would enable the moulder to know why certain effects were produced and the causes underlying them, and would remove the present tendency of the men blaming each other for any troubles which occur in the foundry.

If the training of the apprentices could be so extended as to include provision for these important additions, then a large step forward would have been taken to make the moulder fully qualified to undertake the more responsible positions in the foundry. Another advantage which would follow from such a step would be to make the trade more attractive as a career for the boy leaving school. At the present time the trade suffers from the more obvious disadvantages which strike a visitor to a foundry on the occasion of his first visit. The work appears dirty and to lack any claim to be considered as highly skilful, and the condition of many of the foundries is somewhat discouraging as a first impression. The fact that these impressions are almost entirely erroneous is very difficult to give to those about to enter a trade. The result has been that the more ambitious youths have shunned the foundries and taken to the engineering or patternmaking shops, and, finding opportunities for technical instruction specially suitable for these occupations, they have succeeded in getting many managerial positions in the foundries, in addition to their own particular works.

It is obvious that the lack of moulding experience of such a foundry manager is a serious disadvantage to him, especially when he is confronted with difficult casting problems, and that it would have been far wiser for the manager to have received an all-round training as a foundryman to qualify for the position. Therefore, there is a greater possibility for the future foundry managers to be chosen from the foundry, providing that the training can be so arranged that the foundrymen can acquire an all-round knowledge and experience of their trade, and that suitable care is taken in the selection of the boys who undertake the foundry as a career.

That it is possible to select suitable youths for the foundry has already been proved by one of the largest firms in Sheffileld, who have two secondary school boys recently started in their foundry, and have in addition a youth who is studying in the evening classes for matriculation. It is from this type of youth that the future leaders of the industry will most probably be drawn, and anything which can be done to attract such boys should be very carefully considered and given every encouragement by all concerned.

A Special Foundry Course.

In the report which the Sheffield Advisory Education Committee have presented to the foundry trade will be found a very useful contribution towards the solution of this difficult foundry problem. In the first place it is recommended that the boys should commence evening classes immediately after they have left their day schools, and that the subjects should include English, arithmetic and a special course in chemistry which is to be arranged specially suitable for the foundry boy. This evening tuition will be available at many of the Sheffield schools, so that the boy is not confronted with the difficulty of having to travel a long way to and from his evening school.

At the age of sixteen it is expected he can commence an intermediate study which will prepare him for the final course to be established at the Department of Applied Science of the University. In this two-year intermediate study he will take mathematics, machine drawing and the chemistry of metallurgy, and at the conclusion of the final course at the University he will be able to qualify for a special foundry technical certificate which the University has decided to award.

There is no doubt that this special course of study will make a direct appeal to the ambitious type of boy, especially as he finds that the foundryman's training evidently contains ample scope for him to acquire much useful scientific knowledge and provides him with opportunities for securing honours on his own merit.

The report further deals with the encouragement which will be necessary for the firms to give to the boys in order to influence them to attend the evening classes. A good plan which has been adopted by many firms in the district is to give the apprentices an advance in their wages of one shilling per week for each subject they succeed in passing, so that it would be possible for an apprentice attending evening classes to obtain an additional three shillings pay if he is completely successful. In addition to this, the firms also remit the fees providing that 75 per cent. of the attendances have been made.

The actual recommendations of the report read: "In order that satisfactory technical education be established for boys in the Sheffield foundry trade, the employing firms, where apprentices are not bound by indenture, should agree to make definite arrangements for the training of the boys in their foundry.

"That whether the boys are indentured or not, encouragement should be given them, by increase of wages or otherwise, to attend regularly evening classes and to make progress in studies bearing on their occupation."

If such recommendations are carried out by the foundries, there can be no doubt that the trade will be made very much more attractive to the boys about to enter the trade, and that instead of taking the first boy applying at the gates for a job it will now be possible to adopt a sound system of selection, and thus ensure that the high skill required to execute many jobs in the trade will be retained and developed among the most intelligent men in the country. With the adoption of such a system of education in the foundry trade, there will be no necessity to go outside the ranks of foundrymen to fill any office or position in the works, and the practical and scientific training of such men will improve the efficiency of the foundries and establish the industry on the most secure foundation.

Dilatometric Analysis of Alloys, with Special Reference to Cast Iron.*

By Pierre Chevenard.

[*Translated by V. C. Faulkner.*]

INTRODUCTION.

The Industrial Importance of Thermal Analysis.

The principal methods of metallography comprise, apart from chemical analysis, micrography and thermal analysis. Micrography reveals the psycho-chemical and structural state of a sample at ordinary temperature; it determines the entire effect of any treatment, but it gives no information, at least directly, as to the mechanism of this treatment. Thermal analysis, on the other hand, allows of the visualisation and registering of the transformation of an alloy during the period concerned, and to envisage the temperature, the speed and the intensity; this information is essential for the carrying out of thermal treatments.

Diverse Methods of Thermal Analysis.

Methods for thermal analysis may be divided into two groups:—Thermal methods (the chronographical methods, as used by Roberts-Austen and Dejean) relate to the calorific properties of alloys. Their use is very general, because a change of state is invariably accompanied by thermal phenomena, more or less intense and more or less defined; they are equally applicable to both solid and liquid bodies. Their sensitiveness, however, depends very largely upon the speed of heating and cooling.

They are useless for the study of very slow reactions. Moreover, they do not allow of the quantitative comparison of observed phenomena when the speed varies between large limits. This inconvenience is very serious when related to the study of thermal treatment, a subject which has for one of its objects the rendering more clear of the effect of speed of heating and cooling.

Physical methods, based upon the study of expansion, electrical properties, magnetism, etc., do not exhibit this fault. They allow of the study of slow reactions and a quantitative characterisation of transformations.

Principles Underlying Physical Analysis.

The observed manifestations during the heating and cooling of alloys show up:—(1) The *specific transformation* of the constituents. (a) *Allotropic* transformations with change of phase; (b) *abnormal* transformations without change of phase; (c) *decomposition* of a phase out of balance. (2) *Reactions between phases.*

The close study of these phenomena therefore show, (1) followed in all its details, the mechanism of the reaction during the time of operation, and to receive from it an appreciation of the importance of the phenomenon to which it refers. (2) To control, after trial, the results of a reaction, because, according to the amplitude of the physical properties of the constituents and to the intensity of their specific directional change, one can approximately evaluate the proportion of each.

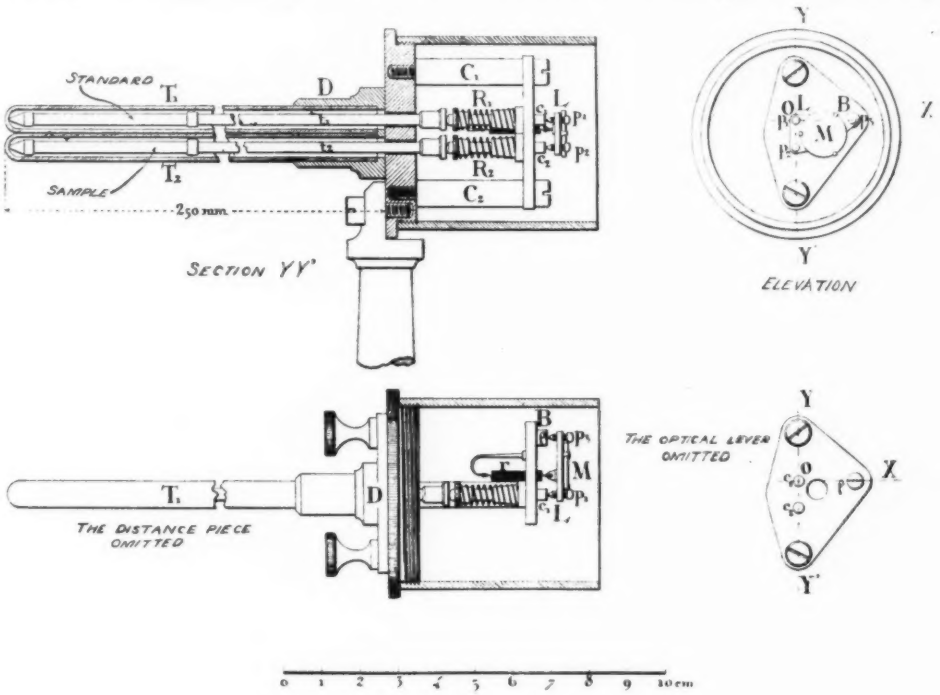

FIG. 1.—DIFFERENTIAL DILATOMETER—ORIGINAL TYPE.

Advantages Shown by the Dilatometric Method.

Amongst the methods used for the physical analysis of solid bodies, that which is based upon the observation of the phenomenon of dilatation appears to be the most rational, the easiest, and the most precise. However, changes of state of substances are always accompanied by a variation of volume. The amplitude of the phenomenon is remarkable, on account of it being so easy to measure in a large number of industrial products, such as the alloys of iron, bronzes, silica bricks, etc., but even in a case where the dilatometric phenomenon is quite small, as in Duralumin, it is always possible to make an analysis even when the manifestation is quite small, if a suitable apparatus is available. However, the results of dilatometric analysis are easy to interpret; the dilatation of an aggregate does not differ redically from that which can be anticipated from the law of mixtures. The dilatometric method presents,

* A Paper read before the Newcastle Conference of the Institute of British Foundrymen, on behalf of the Association Technique de Fonderie.

unlike the electrical and magnetic methods, the advantage of distinct sensitiveness to secondary reaction, such as impurities, thermal history, and allied parasitical phenomena which are unable to mask the essential facts. It is proposed to expose the technique of dilatometric analysis, such as has been developed in the laboratories of the Imphy Works of the Commentry-Fourchambault-Decazeville concern, by taking steel and cast iron as examples, and it is proposed to pass in review some of the results which have been obtained.

Technique of Dilatometric Analysis.

*The Differential Dilatometer**.—(1) The apparatus used for the determination of the dilatation of a sample utilises a suitable standard sample which is heated to the sample temperature. For the play of the single mirror (Fig. 1) moving around two rectangular axes, OX, OY, the apparatus photographically makes a curve, of which the co-ordinates are (1) the expansion of the standard sample which acts as the axis of the abscissae, and which has reference to the temperature communicated to the two samples. (2) The difference in expansion of the two samples.

The Standard Sample.

In order to play the double rôle of being able to compare samples, and as an indicating pyrometer, the standard sample must possess the following properties:—(1) Inoxidysability and rigidity in the region of the temperature where it is used; (2) it must definitely fulfil the law of reversible and regular expansion. In some cases, such as iron, copper, aluminium, it is often possible to utilise a nickel-chrome-tungsten alloy, known as Pyros, which possesses to a high degree the necessary qualities. It is possible to use an apparatus employing Pyros up to 1,100 deg. C., or even 1,200 deg. C.

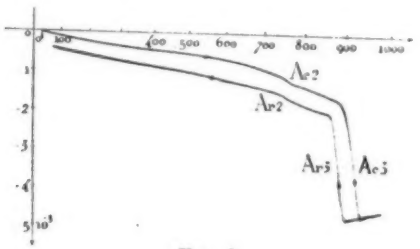

FIG. 3.

Swedish Iron C. 0.035; Pyros standard used. Ac2-Ar2, transformation without change of phase; Ac3-Ar3, Allotropic change with change of phase.

Details of the Apparatus.

The standard samples chosen should possess an average and similar expansion to that of the sample, so that one can, without giving inconvenient dimensions to the diagrams, admit of a high range as regards the ordinates. Thus, the differential apparatus is sensitive. It shows up directional changes, from the normal thermal expansions, and also the very small jogs which are liable to be masked through the rapid rise of the true dilatation curves. Another quality shown from the use of an expansion pyrometer is that the apparatus is robust, reliable, and is completely fool-proof. The curves are entirely free from accidental variations. It is possible, by a graphic elaboration, to trace the curves obtained, which will accentuate the slightest abnormality in the curve. The clearness of the curve is a great help to rational conclusions. From this point of view, the differential dilatometric apparatus appears to present a definite advantage over apparati giving direct readings which rely upon the construction of a curve by a series of points, and incorporates the enregistering by a galvanometer, which latter is always liable to be affected by outside conditions.

Uniformity of Temperature.

The working of the dilatometer presupposes that the two samples are kept constantly at the same temperature. To what extent is this condition realised? Many experiments have been carried out to determine this. In order to ensure this thermal uniformity, samples of the same mass as the standard are used, whilst their calorific capacities should have but small differences. The apparatus is centred in an electric furnace which is provided with a nickel copper muffle. Because of these precautions, equality in temperature is established within two or three degrees, except when the sample is outside its thermal stability as a result of a transformation. It would appear in this case to give a parasitic jog, of which examples will be given.

In order to eliminate them, it is sufficient to place the standard sample in the inside of the sample to be tested. In the apparatus shown in Fig. 2 the pyrometer needles very lightly touch the sample, and experiences the same differentiation

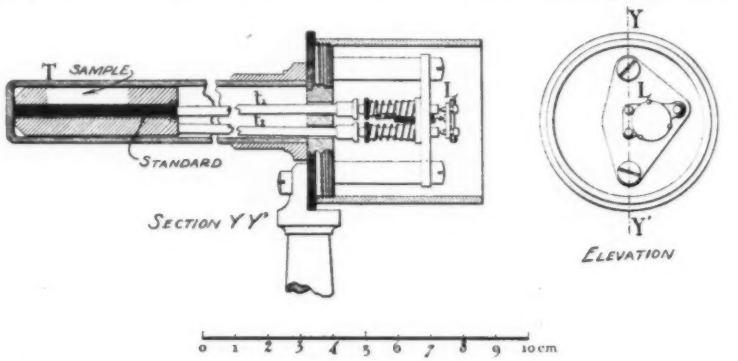

FIG. 2.—DIFFERENTIAL DILATOMETER. THE STANDARD IS ENCLOSED IN THE SAMPLE.

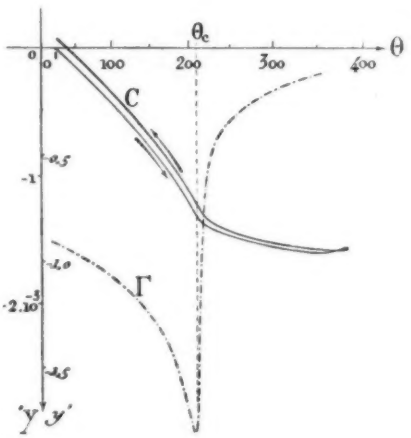

FIG. 4.

Reversible transformation of Cementite directional change. Standard used was electrolytic iron. C = Registered Curve; Γ = Derived Curve; θc = Curie's Point.

* For detailed description see "Rev. de Met. Mem., 1917, vol. XIV, page 610.

in temperature. When reading a diagram, it is easy to distinguish true manifestation, as parasitic jogs are always localised in a straight temperature interval, and of which the direction can be regularly visualised. Also, as the sample is hollow, it is more difficult to prepare than a cylindrical sample, such as used for the first apparatus. This latter is principally used, and is to be recommended.

Calculation of the Co-efficient of Expansion.

The differential dilatometer is not apparatus simply for thermal analysis, as it also allows of

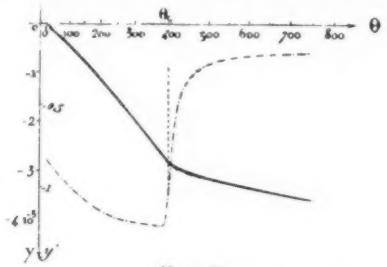

FIG. 5.

Reversible transformation of 45 per cent. ferro-nickel, Pyros being used as standard. The dot and dash line is the derived curve. θc. Curie's point.

the measuring of the expansion of bodies of all temperatures less than 1,100 to 1,200 deg. C. This evaluation is derived from the graphic determination of the results. The operation gives clear diagrams, which is an aid to clear interpretation. The true co-efficients calculated from this method are obtained with a precision amply sufficient for practice. The true error rarely exceeds $0{,}2.10^{-6}$.

Cast Iron.

Ordinary cast iron is essentially formed by the association of ferrite, cementite, and graphite. When the cooling from the liquid state is rapid, the constituents to be associated with steel are found. These are austenite and martensite. It is proposed to deal with first of all the dilatometric properties of these constituents, then directional changes and mutual reactions. As this is a *résumé*, it will suffice to deal with the features of the dilatation diagrams and their physiochemical signification. The interpretation of these features will be discussed in detail in the finished memoir.

Constituents of Cast Iron.

Iron (Fig. 3).—This diagram relates to a sample of Swedish iron practically free from carbon (C = 0.035 per cent.).

The magnetic transformation is marked by a dilatation directional change Ac2 – Ar2, at 770 deg. C., which is reversible, and which con-

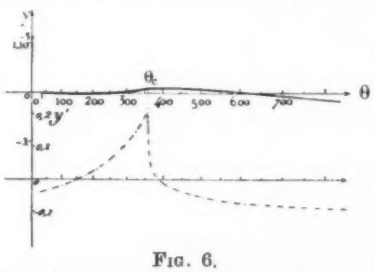

FIG. 6.

Reversible transformation of pure nickel. Pyros standard used. θc, Curie's point. The derived curve is shown dotted.

sists of a rapid variation in the dilatometric properties in the region where magnetisation disappears. (Curie's point.)

The radiographic analysis by Westgren and Phragmen confirm the previous conclusions of Grenet and Weiss, showing that these transformations are carried out without change of phase. The region of the stable alpha state at cold extends from the absolute zero to 920 deg. There is not sufficient space available to deal with beta iron.

On the contrary, the transformation Ac3 – Ar3 definitely corresponds to a change of phase: Alpha ⇌ gamma. Stable gamma iron when hot possesses a crystalline system (cubic with centred facets) and physical properties quite distinct from this system and the properties of alpha iron. This allotropic transformation is sometimes thought to be brought about by a contraction of Ac3, which is small when the iron is pure, but extended when the iron contains carbon, oxygen, etc. The existence of a bend at the start of the point Ac3 of the dilatometric curve is thus characteristic of the impurities of iron.

Cementite has been isolated by Professor

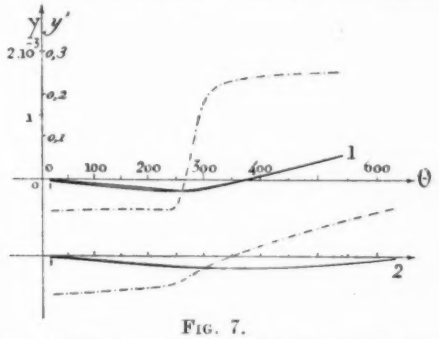

FIG. 7.

Reversible directional change of a Cu-Al solid solution. The full line is the registered curve, and the dotted one the derived curve. Curve 1 contains 8.64, and Curve 2 3.92 per cent. Al.

Arnold, who used a dilute hydrochloric acid solution, which was electrolysed by taking as the cathode a sheet of lead, and for the anode a sheet of carbon steel. The iron in this steel alone is attacked, and the insoluble cementite is precipitated as a black powder. This powder titrated with a few drops of silicate of soda and when compressed in a mould supplies a sample sufficiently solid for dilatation tests.

Cementite, having ferro-magnetic properties, possesses a dilatation directional change which is definitely pronounced (Fig. 4). Curie's point is found about 210 deg. C. This point corresponds with the peak in the derived curve.

All ferro-magnetic bodies and alloys such as alpha iron, cementite, magnetite, ferro-nickel, ferro-cobalt, etc., present a directional change of this character. But the direction and intensity of the phenomenon varies from one substance to the other. (1) In a 45 per cent. ferro-nickel shown in Fig. 5 the dilatation directional change which accompanies the magnetic transformation is definitely comparable with that of cementite. The curve for pure nickel (Fig. 6) symmetrically coincides with the preceding ones, so far as the horizontal axis is concerned, but in every case the bending point in the resulting curve coincides with Curie's point, as revealed by thermo-magnetic methods. It should be noticed that the reversible directional change in dilatation is not only met with in ferro-magnetic bodies. Thus solid solutions, such as copper-aluminium alloys (Fig. 7), show it up very clearly about 250 deg. C.

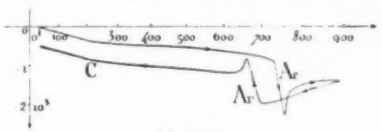

FIG. 8.

A Eutectoid Carbon Steel. (C. 0.85). Pyros standard used.

Diagram 2 of Fig. 7 calls for another remark. The resulting curve shows a bend which the appearance of the first curve would not pre-suppose. This result shows the superiority of an apparatus giving continuous registration, associated with clear tracing and devoid of outside interferences. The directional change of cementite is shown in all aggregates where it exists in the free state, such as *carbon steels* (Figs. 8 and 10) and *white irons*. A quantity of cementite corresponding to a carbon content of 0.05 per cent. only appears on the dilatation diagram when the derived curve is traced. This phenomenon of iron carbide constitutes a pointer, and even contains something of an element of quantitative approximation.

Graphite.—Fig. 9 has reference to a sample cut from an Acheson electrode. A sample of agglomerated Ceylon graphite mixed with silicate of soda has given a similar diagram. Graphite is only slightly expandable, and is free from thermal singularities. This small expandability brings about the rupture of the lamellæ of graphite when cast iron is subject to a transformation incorporating important changes of length. It results in swelling and in porosity.

Complex Cementite.—Manganese, chromium, vanadium, tungsten, etc., also form definite compounds with carbon. These carbides associate themselves with the cementite in cast iron and

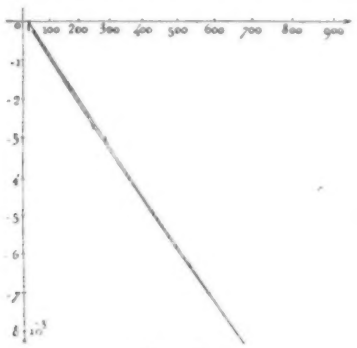

FIG. 9.

Graphite Electrode. Pyros standard used.

special steels. Fig. 11 is a group of diagrams obtained from cast irons all carrying about 4.5 per cent. of combined carbon and manganese contents ranging from 0; 0.75; 1.6; 2.9; 4.0; to 8.1 per cent. Curie's point is seen to be retrograde, and this continuously, which proves that manganese carbide forms a solid solution with Fe3C.

A similar conclusion is to be drawn from Fig. 12, which relates to chromium cast iron. In these special cast irons, of which the combined carbon contents is practically the same (4.5 per cent.), the lowering of Curie's point is due to the cementite, and is proportionate to the manganese or chrome content (Fig. 13). Thus, according to the position of Curie's point, which corresponds, as regards cementite, it is possible to appreciate that if this latter is pure, or if it contains an element such as managanese, chrome, etc. By this method the changes of the carbide in a steel during the course of heat treatment can be followed.

Pearlite-Eutectoid Steel.—Pearlite or the iron cementite eutectoid is encountered in all iron-carbon alloys in the instable state. In order to study these properties, a steel containing 0.85 per cent. carbon, which practically consists of pure pearlite (Fig. 8). About 730 deg. C. iron and cementite react in order to produce austenite, a solid solution of the carbon in gamma iron. This reaction, which is isothermic, according to the phase rule, is accompanied by a contraction. The

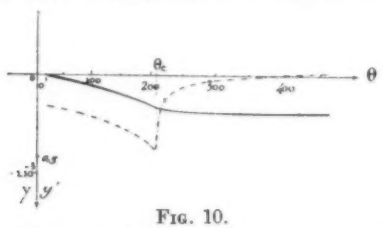

FIG. 10.

Cementite directional change in 1.15 per cent. Carbon Steel. Electrolytic Iron used as standard.

thermal phenomenon which accompanies this creates a difference of temperature between the standard sample and the steel sample. This difference tends to be narrowed as soon as the reaction finishes. That is why the normal contraction is prolonged by a parasitic bend, but it is easy to make an abstract from it, and attention being drawn to this accessory phenomenon any false interpretation of the bends, will be avoided. The curve C is nothing else but a directional change of the cementite.

Austenite.—Pure austenite—that is, a solid solution of the carbon in gamma iron—is only stable above 700 deg. C., but it exists partially unaltered at closely approximating temperatures, when it is subjected to a quick cooling from high temperature (super-quenching). By such a treatment, pure austenite is never obtained, even when starting with an alloy consisting solely of iron and carbon. It thus becomes necessary to utilise a steel carrying an addition, such as manganese, which allows one to take into consideration this foreign body in the quantitative interpretation of the results.

Fig. 14 refers to a manganese steel containing

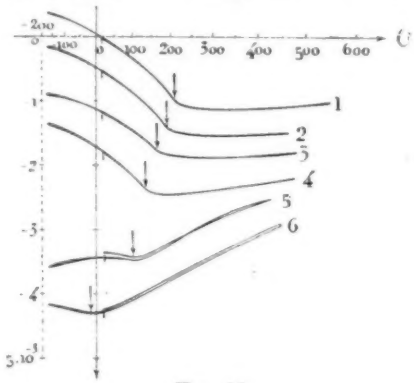

FIG. 11.

Cementite directional changes in complex Cementites in manganiferous Cast Irons. Electrolytic iron used as standard. The carbons averaged 4.5 per cent, and the manganese ranged from nil in Curve I to 8.1 per cent. in Curve 5.

carbon 1.5 and manganese 2.05 per cent. quenched from 1,150 deg. C. in water, and tested beside a standard sample consisting of electrolytic iron. At the beginning of the experiment the alloy is magnetic, and the microscope shows up austenite free from martensite. This austenite is very dilatable, as it shows a clear inclination in curves 1, 2, and 3. Moreover, it is stable when re-heated until the temperature exceeds 325 deg. C. Then the curves 1, 2, and 3 are almost reversible.

At 350 deg. C. (Cycle No. 4) the austenite rapidly decomposes with the generation of heat, which creates parasitic bend (A), which is well defined. The return curve of Cycle 4 is almost horizontal. It shows that the iron has returned to the alpha state. Moreover, it shows a directional change of the carbide C1, and proves that the Austenite decomposes into ferrite and carbide.

But the point C is below 210 deg.; the carbides liberated by the decomposition of the Austenite contain manganese, this element being divided between the complex cementite and the ferrite.

As the heating progresses, phenomenon C decreases, and in a steel heated to 850 deg. C.

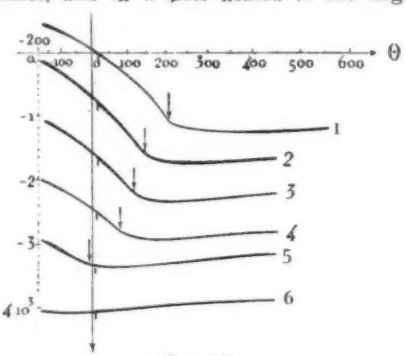

FIG. 12.

Cementite directional changes in chrome cast iron. The carbon averages 4.45 per cent., and the chromium ranges from nil. in Curve 1 up to 8.78 per cent. in Curve 6.

(Curve 8) the temperature C_2 is clearly lower than that of C_1. Thus the co-efficient of the division of the manganese between the carbide and the ferrite varies according to the temperature to which the sample has been raised. Dilatometric analysis shows this change of composition.

Martensite.—Martensite—a constituent associated with quenching—cannot be obtained in a

pure state. The transformation which gives rise to its production is effective at low temperature, and is never complete. Martensite is always accompanied by an excess of Austenite. Also, the dilatation directional changes characteristic of the decomposition of these two constituents will superpose themselves in the return curve (cooling).

If a eutectoid steel is quenched from very high temperature so as to obtain, in the Martensite, a considerable percentage of Austenite, then on reheating (Fig. 15) an important contraction is

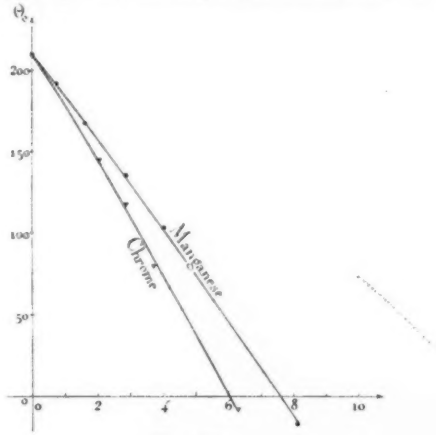

FIG. 13.

Variation of the temperature of Curie's point with the chrome or manganese content in cast iron, carrying about 4.5 per cent. of combined carbon.

noticed, but the speed is very variable according to the temperature. One is thus led to believe that this curve is the resultant of two phenomena —(1) a continuous contraction, which corresponds to the decomposition of the Martensite, and (2) a localised expansion, with a parasitic jog A, which more or less neutralises the preceding contraction and which has reference to the decomposition of the Austenite. On the return curve, after reheating to 700 deg., the cementite directional change (c) has exactly the same value as in a steel heated to 800 deg. C. The Sorbite is therefore an aggregate of iron and cementite, and is of the same composition as pearlite.

In a second experiment the steel was quenched at 800 deg. C. in order to ensure a small excess of Austenite, and gave the curve shown in Fig. 16, in which (1) the cementite directional change does not exist in the quenched steel re-heated to 250 deg. C. This shows that in Martensite the carbon is in a state below and not in the form of

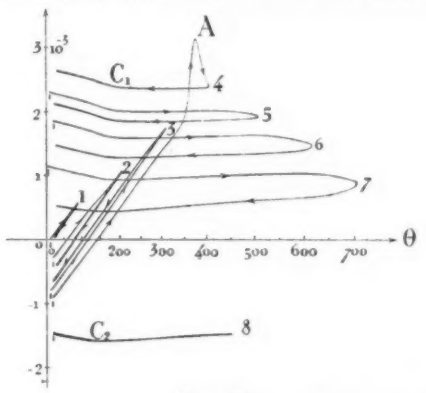

FIG. 14.

Cycles of heat treating of Austenite, obtained by superquenching a manganese steel. C = 1.50; mn. 2.05 per cent. electrolytic iron used as standard. A = Parasitic gob. C_1-C_2 = Directional change of the manganiferous Cementite.

cementite invisible under the microscope. (2) The directional change C. appeared progressively, and the rate of this is definitely parallel to the decrease in the hardness.

The Graphitisation of Cementite.

In order to throw light upon the rôle of silicon and manganese, the author prepared a series of synthetic cast irons in an electric laboratory furnace, using pure raw materials consisting of electrolytic iron, graphite, ferro-silicon, and alumino thermic manganese. The alloys were cast at 1,400 deg. C. into cast-iron ingot moulds so as to form rods of 4 mm. diameter. Under such conditions

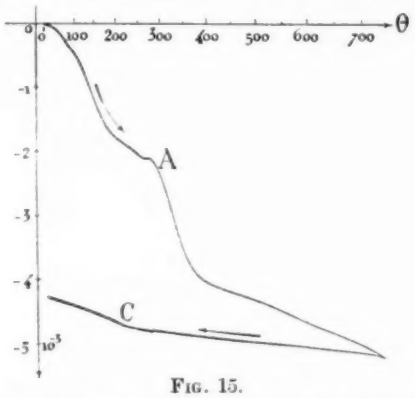

FIG. 15.

Thermal history of a 0.85 per cent Carbon Steel quenched in water, from 1,150 deg. C. Pyros was used as standard. A = Parasitic jog relating to the decomposition of the Austenite. C = Cementite directional change.

solidification becomes extremely rapid, and the irons usually turn out white. Moreover, one can definitely associate with it a true martensitic quench. In all the experiments to be described the speed of heating was kept practically constant at about 250 deg. per hour.

Very Pure White Iron A.—This iron showed the

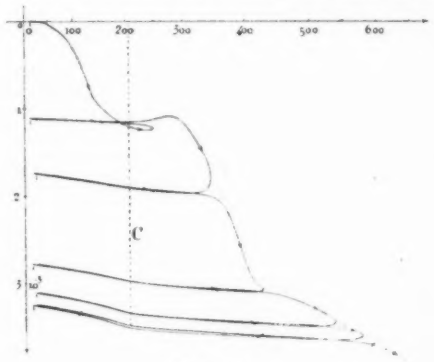

FIG. 16.

Reheating cycles from .85 Carbon Steel quenched in water from 800 deg. Cent. Electrolytic Iron standard used. C = Progressive appearance of Cementite directional change.

following composition:—C.C., 4.44; Gr, nil; Si, 0.14 per cent.; and Mn, trace. The first cycle, shown in Fig. 17, shows in a striking manner the reversible cementite directional change C. On curve 2 there is recorded, on heating up the directional change C, the jog, given by the transformation of the pearlite Ac, and above 1,000 deg. C.,

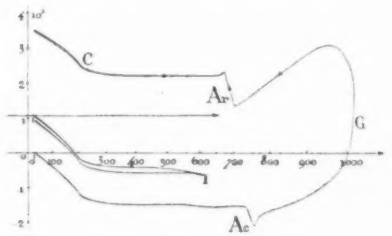

FIG. 17.

Synthetic Cast Iron after casting. C. 4.44; Si 0.14; Mn. Tr.; Pyros standard used. C. Cementite directional change; G. Graphitisation; Ac-Ar, Allotropic transformation.

an ascension G. Then on cooling the formation of the pearlite Ar and the directional change given by the cementite.

On careful examination the return curve shows that the directional change of the cementite is

less intense than on heating. This result is confirmed by micrographic observation, which shows graphite particles after cycle 2. Thus the phenomenon G relates to the graphitisation of the cementite. It is thus shown that the reaction starts at high temperature and that its speed is slow.

The Influence of Silicon.

Table I shows the composition of the samples experimented upon.

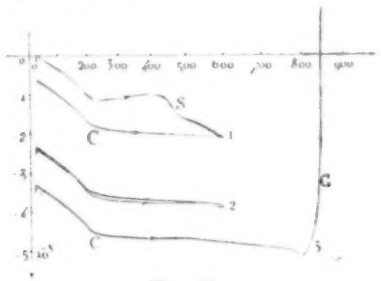

FIG. 18.

Synthetic Cast Iron B, after casting. C. 4.8; Si 0.85; Mn. Tr.; Pyros standard used. C, Cementite directional change; S, Reheating bend from Martensite and doubtless Austenite. G, Graphitisation of Cementite.

Table I, showing composition of samples used for ascertaining the influence of silicon.

Sample.	Tot. C.	Si.	Mn.
B.	4.80	0.85	Tr.
C.	4.85	1.70	,,
D.	4.42	2.38	,,
E.	4.36	4.78	,,

It is well known that silicon is an energetic accelerator of graphitisation. With 0.85 per cent. Si, the graphitisation of sample B started at 800 deg. (curve 3 of Fig. 18), and the phenomenon is rapid. If the temperature is taken to 1,050 deg. C. the cementite is totally decomposed. Proof of this is given by referring to the novel dilation cycles after the phenomenon G (cycles 4 and 5 of Fig. 19). This aspect of the diagram is profoundly different. The directional change of the cementite has practically disappeared, and the jogs Ac and Ar correspond to the stable iron-graphite system.

The diagrams of the samples C, D and E, of which the silicon contents are in increasing amounts, call forth the same observations. As silicon is added so the temperature of graphitisation (G) decreases, and this practically continuously until it stabilises itself at 600 to 650 deg. C., when the silicon content will have reached 4.0 per cent.

Graphitisation is independent of the Ac transformation. According to silicon content, the ascending curve G starts either above or below the Ac point. On Fig. 20 the Ac point is seen to be right in the middle of the graphitisation period.

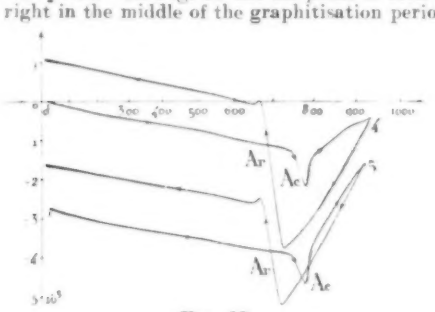

FIG. 19.

Synthetic Cast Iron B, after graphitisation. Same sample as Fig. 18.

In all these diagrams the first thermal cycle shows a bend S on heating analogous to that exhibited by quenched steels. Thus casting in chills sets up two quite distinct phenomena, though both are referred to under the name of "chilled" (quenched). The first is the production of the unstable system, iron—cementite, and the second a true martensitic quench, similar to that of steel.

Influence of Carbon.

The cast iron samples just outlined have a carbon content of about 4.5 per cent. It is now proposed to consider one containing much less carbon, sample F. Its analysis is C, 1.68; Si, 1.20 per cent.; and Mn, trace. (Fig. 23).

The intensity of the jog S on heating is very

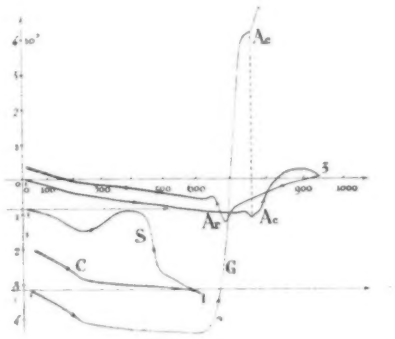

FIG. 20.

Synthetic Cast Iron. C. after casting. C. 4.85; Si 1.70; Mn. Tr.; Pyros used as standard. C. Cementite directional change; S, Reheating bend; G, Graphitisation; Ac-Ar, Allotropic transformation.

pronounced. The graphitisation (G) scarcely commences until 875 deg. C., whereas in an iron carrying the same silicon contents and 4.5 per cent. C., it would occur from 650 deg. C. This confirms the well-known fact that silicon and

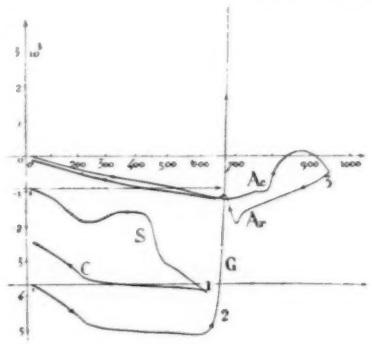

FIG. 21.

Synthetic Cast Iron. D, after casting; C. 4.42; Si 2.39; Mn. Tr.; Pyros used as standard. C, directional change of the Cementite; S, bend on reheating; G, Graphitisation; Ac-Ar, Allotropic transformation.

carbon help graphitisation. Above G the dilatation curve experiences a change of direction P, and beyond becomes sensibly reversible. Whereas on cooling the graphitisation characterised by the ascension of the curve returns at temperatures

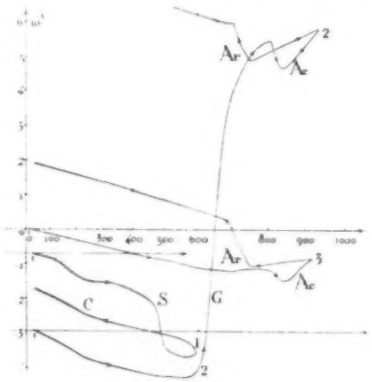

FIG. 22.

Synthetic Cast Iron. E, after casting. C = 4.36; Si 4.78; Mn. Tr.; Pyros standard used. C, Cementite directional change; S, Reheating bend; G = Total graphitisation. Ac-Ar, Allotropic transformation in the Iron-Graphite system.

lower than that of P. The temperature of the phenomenon P corresponds to the line of Roozeboom's diagram—the limit of the solubility of graphite in austenite. Above P the alloy is a

homogeneous solid solution, and graphitisation ceases, to re-occur again below.

Complex Phenomena Observed in Cast Iron Contained in Silicon and Manganese.

The iron used contained C, 4.20; Si, 1.34; and Mn, 4.06 per cent (Fig. 24). The manganese tends

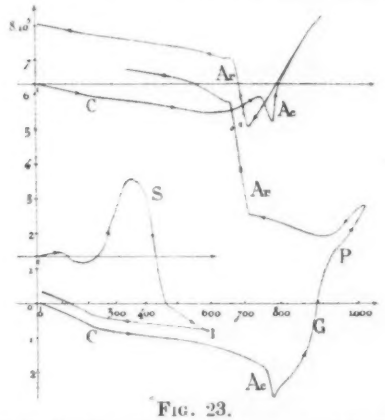

FIG. 23.

Synthetic Iron F, after casting. C = 1.18; Si 1.20; Mn. Tr. Pyros standard used. C = directional change of the Cementite; S, Reheating Bend. G = Graphitisation. Ac-Ar, Allotropic modification. P = Total solubility of the carbon.

to counteract the action of the silicon on graphitisation. It enters into the constitution of complex cementites, and renders the iron-carbon alloys self hard. Complex phenomena are thus to be expected in the course of reheating and iron containing both silicon and manganese which has

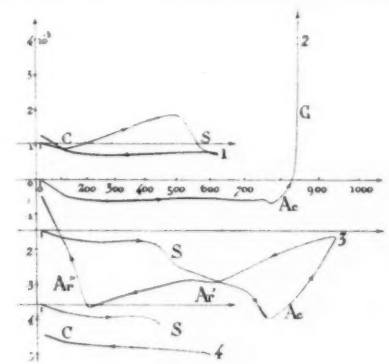

FIG. 24.

Synthetic Cast Iron after casting. Pyros standard used. C. 4.20; Si 1.34; Mn. 4.05. C, Cementite directional change; S, Reheating bend; Ac, Allotropic transformation on heating; Ar'-Ar'', Allotropic transformation on cooling; G, Graphitisation.

been chill cast. It is proposed to show by an example that it is possible to clear up these obscure phenomena.

Cycle 1 of Fig. 24 shows first of all about 125 deg. C., the directional change of the complex carbide, then the curve takes an ascending course.

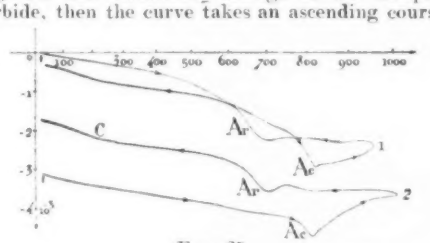

FIG. 25.

Very grey impure Cast iron. C. 3.30; Si 3.00; Mn 3.25; S. 0.011; P. 0.082. Pyros standard used.

After a jog S, it returns to nearly horizontal, and the directional change of the carbide again appears with an added intensity. The explanation is simple. The cast iron cast in 4 mm. rods was partially super-quenched; that is to say, it contains a certain quantity of austenite with the martensite, which induces high dilatability. This austenite and martensite retains some carbon in solution. The heating S precipitates the carbon, which increases the directional change of the latter.

From curve 2 the graphitisation (G) is seen to appear about 800 deg. C.; that is to say, about 150 deg. higher than if no manganese was present. The stabilising action of the manganese on the

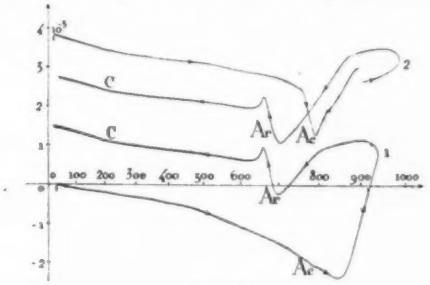

FIG. 26.

Black Heart Malleable Iron. C. 1.1; Si 0.77; Mn. 0.16; S. 0.05; P. 0.16. Pyros standard used.

cementite is again apparent. The return of this cycle No. 2 has not been registered, but as the manganese renders the alloy self-hardening a quench during the course of cooling is foreseen.

It is this which appears on cycle No. 3, the jog S of heating proves the existence of a previous quench. Besides, on the cooling portion of this cycle (3) the transformation Ar is doubled into

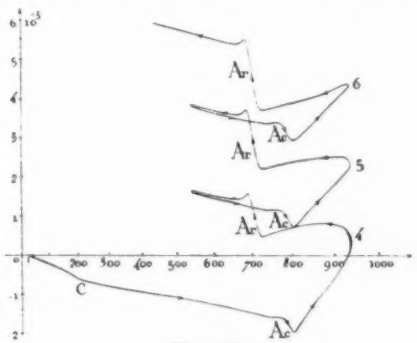

FIG. 27.

Chilled portion of a roll. Pyros standard used. C. 2.60; Si 0.95; Mn. 0.25; S. 0.75; P. 49.

two manifestations Ar_1 and Ar_2, and this aspect corresponds precisely to a self-hardening, confirmed in its turn by the jog S of cycle 4.

Industrial Cast Irons.

Impure grey cast iron was used containing C, 3.30; Si, 3.00; Mn, 3.25; S, 0.011; and P, 0.082 per cent. (Fig. 25). The graphite was in very large flakes, and because of its size the transformation Ac and Ar is very spread out.

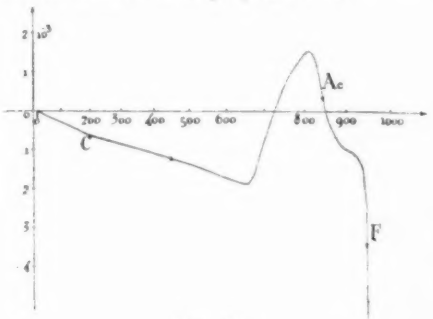

FIG. 28.

Phosphoric Iron, sample cast in bar form. Pyros standard used. C. 3.30; Si 2.10; Mn. .40; S .06; P. 1.35.

Blackheart Malleable.—This sample contained C, 1.10; Si, 0.77; Mn, 0.16; S, 0.05; and P, 0.162 per cent. (Fig. 26). The microscope showed the graphite to exist as nodules in the ferrite.

From curve 1 on heating there is no directional change C, and the transformation Ac is scarcely apparent, or very spread out. The ascending

portion doubtlessly corresponds to the solution of the graphite in gamma iron, a very progressive action because of the form of the condition of the graphite. On cooling the directional change C and the transformation Ar are to be noted.

On curve 2, beyond the transformation Ac—Ar, the directional change (C) of the cementite is noticeable both on heating and cooling. Thus the metal tends to return to the unstable system, which is without doubt because of the low carbon content.

Cast Iron Roll (fragment from the chill).—This sample contained C, 2.6; Mn, 0.25; S, 0.075; Si, 0.95; and P, 0.49 (Fig. 27). The successive cycles between 550 and 950 deg. C show a progressive expansion, which relates to a gradual graphitisation of the cementite. This cementite, which is slightly manganiferous and of a relatively small quantity (the proportion of carbon is less than the normal cast iron content) in contact with a ferrite containing 0.95 per cent. Si, is found in a condition of average stability and decomposes slowly.

Phosphoric Cast Iron.

This sample contained C, 3.30; Si, 2.10; Mn, 0.40; S, 0.06; and P, 1.35 per cent. The curve derived from the first heating (Fig. 28) shows a sharp jog and ends by a sharp drop F. However, the cycles allow of the elucidation of the phenomena. The directional change C shows that the iron initially contains about 1 per cent. of combined carbon. The silicon content being increased side by side with the proportion of manganese, the graphitisation starts at from 600 deg. C, as is shown in curve 3, which is practically free from the directional change C. But this curve 3 shows about 730 deg. C, the directional change Ac_2 of the silico-ferrite. It is known that the silicon

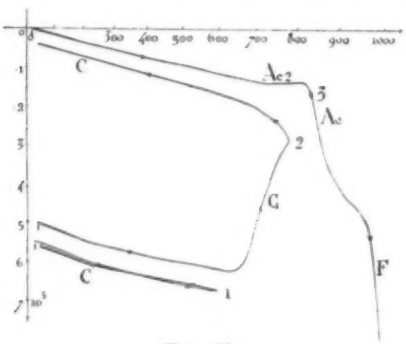

FIG. 29.

Phosphoric Cast Iron. Same sample as Fig. 28. Pyros standard used.

lowers Curie's point of alpha iron. The jog Ac is next shown, and it relates to the transformation of the stable system. However, the temperature of the drop coincides with the melting point of Stead's phosphide eutectic (Fe — Fe_3C — Fe_3P), at about 950 deg. C. This drop therefore corresponds with the release of the sample under the small pressure of the springs of the dilatometer.

Conclusions.

(1) It has been shown that all the phenomena actually known of cast iron have their counterpart in dilatometric curves. Actually it has confirmed the principle results of Charpy and Grenet relative to graphitisation, and obtained by micrography after quenching. But the dilatometric method is much more rapid, easy and sensitive. It allows of continuous measurement, and this continuity appears to be necessary to clear up the phenomena, which are masked, such as those which have been observed in manganiferous cast iron. It is reasonable to hope to obtain, for the graphitisation of cast iron, results comparable with those which are actually obtained for the quenching of steel. Undoubtedly, dilatometric analysis permits of the characterisation of the tendency to graphitisation in a cast iron in the same way as one can set forth the quenching properties of steel. The practical importance of such results should have a strong bearing upon the scientific manufacture of malleable iron.

(2) *Dilatometric analysis* possesses, as does chemical analysis, a dual aspect (*a*) qualitative analysis. The specific directional changes at definite temperatures, as that of cementite, characterise the presence of phases, definite aggregates or solid solutions of which the chemical composition is known. But, though chemical analysis indicates the mass composition of an aggregate, dilatometric analysis gives information as to the nature of the aggregate, and thus constitutes a process of immediate analysis. (*b*) *Quantitative Analysis.*—The size of the directional changes, of which finishes a process capable of quantitative evaluation of the constituent of which the presence is revealed.

(3) Dilatometric analysis is applied not only to large samples obtained by casting or machining, but also from rods prepared by the agglomeration of powdered material as was done in Bilasco's experiment on varieties of silica and in Chaudron's work on iron oxide. Thus it is now possible to study industrial reactions which exist in the solid state such as roasting, cementation, etc.

(4) Finally, independent of dilatometrical analysis, the differential dilatometrical allows of the measuring of expansions in an extended temperature interval, such as the working of a part in machines operating at high temperatures, the choice of foundry enamels, optical glass apparatus, glass soldered electrodes, etc.

Foundrymen Visit Famous Scotch Ironworks.

About 80 members of the Scottish Branch of the Institute of British Foundrymen recently visited the Glengarnock Works of Messrs. David Colville & Son, Limited. The party was met at the station by Mr. Gibson, metallurgist, and Mr. Abernethy, blast-furnace manager, and under their guidance was conducted through the works. Assistance was given by several members of the staff, and as Messrs. Colville had provided one guide to about eight visitors, the various points of interest were fully explained to all present.

A visit was first made to the receiving yard where all raw materials are brought in. The method of calculating the charges of filling the furnaces and of controlling the various elements in the pig-iron were here explained, after which the party went up to the charging platform where a demonstration of charging was given.

The hot-blast stoves were next visited, where the procedure of working and the method of heating the blast were described and opportunity taken to examine an old beam type blowing engine. This engine, which has been working for about 60 years, is still in service, although, since a modern turbo-blower was installed a few years ago, it has been principally used as an auxiliary.

The recovery of by-products was next inspected, and while time did not permit of a detailed examination of the plant, the methods whereby NH_3, tar, boiled tar, pitch, creosote oil, and sulphate of ammonia were recovered from the blast-furnace gases were pointed out by the guides.

The last part of the works to be visited was the laboratory, where a large number of samples of all grades of iron were laid out for inspection. Analyses of the samples were also given, and the members present had an excellent opportunity of comparing fractures and analyses and reflecting on the relative advantages of each method of grading. An interesting exhibit was a new special cylinder pig-iron which Messrs. Colville are now producing.

After being photographed, the party was entertained to tea in the village by Messrs. Colville & Son. Mr. Anderson, the works manager, presided, and took the opportunity of welcoming the members to Glengarnock. Mr. Affleck, the President of the Branch, expressed the thanks of the members for the kindness shown by Messrs. Colville, and for the excellent arrangements made by the works staff, particularly Mr. Abernethy and Mr. Gibson. Mr. Abernethy replied on behalf of the Company, and hoped that at some future visit more time would be available for a more extensive and detailed examination of the works.

The Problem of the Liquid Contraction in Grey Cast Iron.*

By Robert Buchanan, Past-President of the Institute of British Foundrymen.

This subject first had considerable attention given to it by Keep of America, and was further developed by Professor Turner, of Birmingham. The late Mr. George Hailstone conducted an investigation in the same direction, but, unfortunately, did not live long enough to carry the matter to a conclusion. In recent years Mr. Oliver Smalley has made an important contribution to the subject. It is not proposed to bring forward anything which is novel, but a review of the subject, from the author's point of view, may be of interest.

In considering the ultimate result known as liquid contraction, one must begin with what takes place when the iron is being melted as a key to what ultimately takes place when iron cools. Technical terms will be avoided as far as possible, so that one not acquainted with these will be able, it is hoped, to follow and appreciate the matters dealt with.

Changes in Cast Iron on Heating.

When one charges iron into the cupola, and when the melting is about to begin, what takes place? As the iron begins to heat up, but before it becomes fluid, certain changes take place. The phosphorus and sulphur compounds become fluid while the iron is still apparently solid. By the time the graphite carbon has dissolved into the general mass of iron, it is only then that the iron is fluid. It is an interesting fact that when the carbon is becoming, or has become, dissolved in the iron that there is a cessation of rise of temperature of the iron. This latent heat afterwards performs an important part when the iron is cooling down.

When the iron was in a cold condition a certain percentage of carbon was in combination with the iron, and this carbon is known as combined carbon. This carbon is not visible to the eye. The quantity of combined carbon in an iron is really the measure of the hardness of such irons. In the molten state, with all the graphite dissolved in the iron, the whole of the carbon is in combination, and in this stage has no separate existence. The amount of graphite, which is free from the iron when it is cold, is practically the measure of the softness of such iron.

Seeing that the carbon has become dissolved into the molten iron, it has been observed and proved that the molten iron in the ladle occupies less space than it did when charged into the cupola. The molten iron is of greater specific gravity than when it was solid.

The interesting question arises that, seeing we are about to cast with metal which is more dense than what it will be, why we should have to consider liquid contraction in a metal which is going to be less dense once it has solidified. It is hoped to show that what is called liquid contraction is due to solid expansion. It ought to have been stated earlier that liquid contraction—"sinking" and "drawing" are names for the same manifestation.

A number of years ago Professor Turner, by means of his extensometer, showed that at a certain time in the cooling of grey cast iron the casting was larger than the pattern, although it ultimately contracted to the normal $\frac{1}{8}$ or $\frac{1}{10}$ in. per foot, according to the thickness of the casting. It is well known that where castings are all of one thickness little contraction is seen, with special exceptions.

What Cook's "K" Test Shows.

It has to be admitted that some irons show liquid contraction more than others, but the reasons for this are too diverse for discussion now. For instance, high-silicon iron, say, over 3.5 per cent. silicon, readily shows liquid contraction due to the low total carbon present, especially where there is a change of section or boss. Where an iron or mixture of iron will show liquid contraction is readily ascertained by the use of Cook's "K" test. In making this test it must not be forgotten that the influence of the casting temperature is very important.

This "K" test is an attempt to reproduce on the small scale what takes place in a casting of an unequal cooling period. The "K" test piece is run at the heaviest part, and this part naturally is liquid or semi-liquid when the points of the "K" have begun to solidify and expand. Why should they expand away from the centre and thus cause liquid contraction at the centre? The reason of the expansion is that the carbon which was dissolved in the metal is now coming out in the form of graphite, and each particle of graphite is elbowing a space for itself. Why the graphite should elbow its way outwards and away from the heavier part of the "K" the author does not know, and can only surmise.

Under certain circumstances expansion towards the softer part of the casting can be made to take place. Mr. E. H. Broughall, of Coventry, casts quite a number of castings in cast-iron moulds. These are mostly of cylindrical form, and were the moulds in greensand they would require "feeding." But with iron moulds the castings not only do not require feeding, but actually dry in the centre and are perfectly solid. The strains on the mould thus produced are so great that spring washers have to be used to save the snugs from being broken.

Large-Scale Experiments.

The author has cast a number of weights, cubes in shape, and weighing one ton each. These were made in sand moulds and required feeding when cast. This necessity of feeding was due undoubtedly to the moulds yielding to the outward expansion of the metal and not towards the centre. Had these weights been cast in a rigid cast-iron mould they would have undoubtedly risen in the centre and not required feeding.

The conclusion is thus arrived at that liquid contraction in one part of a casting is due to the solid expansion of another part or parts. This solid expansion is largely caused by the amount and size of the graphite flakes extruded during solidification. On the other hand, a deficiency of total carbon will produce liquid contraction, and thus one can have excessive liquid contraction with a No. 1 iron at one end of the scale of softness and again when one gets to the mottled stage. The author's opinion is that one gets a minimum liquid contraction when the carbon is in the condition which one finds in a close No. 4 iron. A definition of this kind is not scientific, but perhaps conveys to the mind of non-scientific foundrymen (if such there be) what it is wished to convey.

Earlier on the latent heat absorbed during the process of melting was referred to. This latent heat is given back during the solidifying of the iron and the extrusion of the graphite. This giving out of the latent heat undoubtedly helps the solid expansion and thus tends to produce liquid contraction. As a matter of fact, at one part of the cooling down there is a cessation of the cooling. This is due to the latent heat absorbed in the melting being paid back.

Hailstone's Experiments on Liquid Contraction.

The late Mr. George Hailstone carried out a series of experiments to show the conditions under which liquid contraction in grey cast iron occurred. This was his thesis for the Carnegie Scholarship which he held, but unfortunately he did not live long enough to complete the inquiry. The following is a summary of his conclusions:—

Hailstone's Summary.

(1) Liquid contraction is accompanied by a lowering of the specific gravity or density; (2) casting temperature is one of the ruling factors in obtaining a dense and solid casting; (3) when castings have been cast with iron hotter than will conduce to liquid contraction, solid and dense

* A Paper read before the Congress held in connection with the Foundry Trades Exhibition.

castings result, hence the series of conditions is: cast hot gives dense castings, medium heat gives liquid contraction, and cold iron gives blow-holes; (4) the more regular the sizes of the microscopical constituents the less will be the liquid contraction; (5) conditions which conduce to a maximum solid contraction conduce to a maximum liquid contraction (the author does not agree with this opinion with respect to grey irons); and (6) gases appear to be held in more intimate contact in cast iron poured at a high temperature, and therefore tend to produce a more solid and dense casting.

Hailstone did not use the thermo-couple or the pyrometer to ascertain accurate temperatures, but used the foundry terms of hot, medium, or cold. His solidity tests were made with Cook's "K" test. The "K" test is an extremely useful guide for the practical foundryman, whether he be scientific—so called—or not.

Keep's and Turner's Tests.

The well-known diagram illustrating Keep's experiments in the expansion of cast iron was further developed by Professor Turner of this city. Keep and Turner showed that with a silicious pig there are two expansions if the iron be free from phosphorus, and three expansions if phosphorus be present to any marked degree. At 1,050 deg. C. the primary graphite is formed; at 900 deg. C. the phosphorus has solidified; and at 730 deg. C. the secondary graphite, or annealing carbon, has come out of solution.

It is these expansions taking place in one part of the casting which accounts for the liquid contraction which takes place in the heavier part. Turner has proved that at one part of the cooling from the molten to the solid condition the casting is actually longer than the pattern. The "feeding" of a heavy boss is really a keeping open of the runner or riser so that liquid iron may get in to replace the iron in the boss which is travelling towards the expanding solidified portions. In low silicon strong irons one may see the molten iron in the feeding head run away as if the bottom had dropped out. This is due, no doubt, to the expansion at the extremities of the casting, due to the formation of the primary graphite at that moment.

Smalley's Experiments.

Mr. Oliver Smalley's experiments, published within the past two years, are of the highest importance. The range of his investigations is so wide that in the space available it is difficult to make an adequate condensed summary.

Smalley experimented with castings of intricate design to test how far numerous contiguous ribs affected liquid contraction. To do so he ran the casting at the heaviest section, a course which would be more likely to produce liquid contraction. As we now recognise, it is, wherever possible, best to run a casting along the light section rather than along a heavy. To run a casting by the heaviest part is not recognised now as being the best course. The heavy part gets heated up by the metal passing through or along it, and so extra heat is being given to a part which does not require it, and so prolongs its cooling period. In short, what is wanted is the equal cooling all over of the casting, however its section may vary. This is an ideal very difficult to carry out, and the use of denseners is one of the means employed to obtain it. It is somewhat unfortunate that many engineers think that the use of denseners is a trick. The author has often to point out that the use of denseners is the introduction of a natural law which is useful to us and to the engineer to counteract a natural law which is hurtful to us. By using denseners we endeavour to get a regular cooling period in a casting which otherwise would be irregular, with hurtful results both to us and the engineer.

Smalley comes to the conclusion that casting temperature of a mixture of iron is more important than the chemical constitution of such mixture. It is rather surprising that he considers a green sand mould gives better results than a dry sand or loam mould. Seeing that he obtained his greatest density from casting in a chill mould, one would have expected better results from dry sand or loam. These moulds more nearly approach the chill mould in rigidity, but no doubt lengthen the cooling period to a greater extent than a green-sand mould will.

Manganese.—The use of irons containing at least 1 per cent. of manganese is advised, if one wants to lessen the liability to liquid contraction. The reason is that manganese lowers the sulphur by helping to form manganese sulphide, which is not a hard constituent. The manganese carbide which is also formed has a high setting point, and crystallises before any other constituent. It is well known that when crystallisation begins it rapidly spreads, and so hastens the crystallisation of the whole mass. In short, it quickens the cooling or setting period of the metal, and thus lessens the size of the graphite flakes. The size of the graphite flakes and their quantity have a great influence as to whether a metal will show liquid contraction or not.

Ronceray's Method.

As is well known, Ronceray recommends for specific cases the use of a very small runner, hot metal, and slow running. The author is aware that in numerous cases this is an excellent cure for liquid contraction, but is not applicable in all cases for obvious reasons.

Finally, for founders who have no facilities for testing the heat of their metal, either by thermo-couples or by the pyrometer, the use of Cook's "K" test is to be recommended. It is simple to use, is inexpensive, and the results readily understood.

Catalogues Received.

Products of an Ironworks.—We have received from Messrs. Newton, Chambers & Company, Limited, of Thorncliffe Ironworks, near Sheffield, a very handsome well illustrated souvenir booklet. In all it takes 68 pages to describe the firm's many activities, which range from pig-iron, through coal, coke, iron and steel works plant, disinfectants to cooking and heating apparatus. It contains a really beautiful coloured picture of the Thorncliffe foundries. The general appearance and quality of the booklet are such as to warrant a stiff cardboard back, though we must admit the present cover is very artistic. We congratulate the firm on having produced a booklet which has few superiors in the engineering world.

Foundry Supplies.—The well-known North-East Coast foundry supply house, Messrs. Lawson, Walton & Company, of St. Nicholas' Buildings, Newcastle-on-Tyne, are furnishing the foundry trade with a filing folder to contain loose leaf catalogue sheets, which are sent out from time to time as new models develop or changes in price are announced. This system has much to commend it, providing it receives the proper co-operation of the foundrymen. We would suggest to Messrs. Lawson, Walton, and other similar firms that all literature should be sent in duplicate, and marked, one copy to be retained by the buyer and the other for the foundry manager's files.

New and Second-Hand Iron, Steelworks and Foundry Material.—Messrs. T. W. Ward, Limited, of Albion Works, Sheffield, have recently published a new brochure describing the service given by the firm through its numerous branches and departments.

THE PHELPS DODGE CORPORATION have removed to 53, Gracechurch Street, E.C.3.

THE 89th annual report of the Boilermakers' and Iron and Steel Shipbuilders' Society states that the membership at the end of 1923 was 38,267, as compared with 94,739 at the end of 1922. As a consequence of the seven months lock-out and minor disputes, the Society spent £155,413. Nothwithstanding the expenditure on the chief dispute, the decrease in their funds for the year was only £180,558, which was practically the same decrease as in the previous year.

THE JOINT secretaries of the South Wales and Monmouthshire Iron and Steel Workers' Sliding Scale Board state that for the three months commencing July 1 there will be an advance in the scale of 0.75 per cent., which will bring the percentage to 61½ above standard. The average net selling price of steel rails (20 lb. per yard and upwards) and steel tin bars (of all weights) for the three months ending May 31 last, which was the period of the audit, was £8 3s. 8.56d. per ton, that being an advance of 1s. 3.73d. per ton over the previous quarter concluding on February 29.

The Manufacture of Light Castings, Pipes and Fittings in India.

The Eastern Light Castings Company, Limited, opened their works at Kulti, Bengal, in 1922, with the object of manufacturing rainwater and soil-pipes and fittings particularly, and light repetition castings of any and every description.

FIG. 1.—PIPE MOULD CASTING FLOOR.—THE EASTERN LIGHT CASTINGS COMPANY.

Situation.

The works are situated beside the East Indian Railway, about 143 miles from Calcutta, and one mile from the well-known ironworks of the Bengal Iron Company, Limited. They cover an area of about ten acres, and have ample space for extension.

Raw Materials.

These are delivered to the stockyard by rail running parallel with the shops. Pig-iron, coke, limestone, etc., are unloaded into trucks carried on flat bogies, which run on a sunken track. By this means they are transferred either to their section in the stockyard or to the cupola as required.

FIG. 2.—MACHINE MOULDING SECTION.—THE EASTERN LIGHT CASTINGS COMPANY.

Buildings.

The pattern and machine shops comprise two bays, and are equipped with a lathe, planing machine, drilling machine, bandsaw, sanding machine, etc., suitable for their class of work. Patterns are made in wood, iron, or stucco as required; the last type being used for master patterns. Special consideration is given to the making of connection patterns and core-boxes for machine plate moulding, as it involves great accuracy.

The main foundry building is a steel structure, with a corrugated asbestos tiled roof. The sides of the building are covered with asbestos sheets to within seven feet from the floor level, the usual practice in India. The roof is provided with north light, so that with the open sides the maximum light is obtained.

FIG. 3.—PATTERN SHOP.—THE EASTERN LIGHT CASTINGS COMPANY.

Melting Plant.

The cupola is operated for continuous melting, and has a maximum capacity of 18 tons per hour. It is of the drop-bottom type. Air is supplied to the cupola by a positive pressure blower capable of delivering 9,800 cub. ft. per min., and driven by an electric motor through countershaft. An oil burner, using compressed air, is used for lighting the cupola.

Materials are conveyed to the charging platform

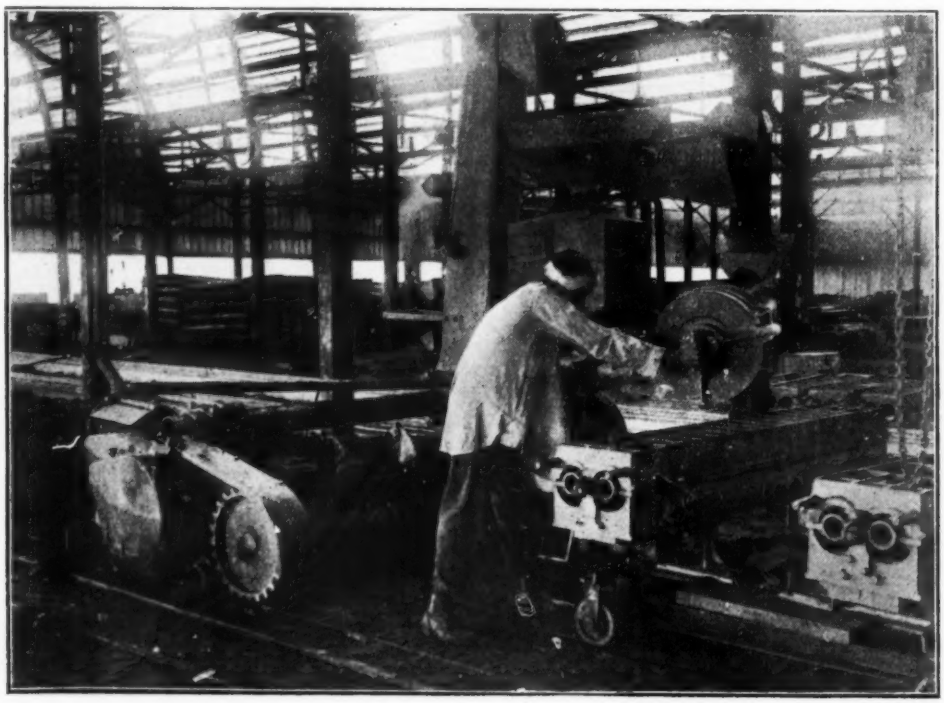

FIG. 4.—BEARDSLEY PIPER SAND SLINGER MOULDING MACHINE.—THE EASTERN LIGHT CASTINGS COMPANY.

by an electric hoist after weighing. A similar system of transfer bogies to those used in the stockyard is used on the charging platform, enabling all materials to be placed on it before charging operations commence. All iron is charged by analysis, and daily records kept.

Moulding Floor.

The moulding shop is divided into twelve bays. A mono-rail system is used to convey molten iron to the casting floors. The cupola spout is a double one, i.e., outer spout can be moved forward by means of a racking arrangement to reach any particular rail. A foot-lever operated by the cupola attendant tilts the spout, thus holding the metal whilst another ladle is run into position. The inner spout is self-slagging.

Moulding Equipment.

Moulding machines with stripping plates are used for making the pipe moulds, and are mounted in pairs. Moulds are rammed partly by hand, and a Beardsley-Piper sand slinger has been installed for the larger sizes. This machine is capable of ramming 10 cub. ft. of sand per minute, and is of the tractor type. Connections and repetition work are made on pneumatic jar-ramming machines. The air-compressor is located in a separate building outside, is driven by a direct-

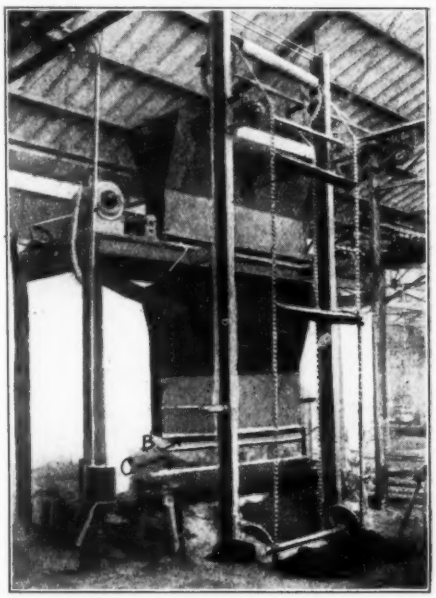

FIG. 5.—CORE-MAKING MACHINE.—EASTERN LIGHT CASTINGS COMPANY.

coupled motor, and has an output of 2,000 cub. ft. per min.

Cores for straight pipes are made on circular hollow arbours of special manufacture, by an electrically operated machine.

Sand is all milled in the usual type of grinding pan, where the first attempt is made at mixing the different grades used. It is then put through a centrifugal mixer, which thoroughly aerates it. From there it is passed through a small mesh riddle, leaving the sand of an even texture suitable for manufacturing purposes. Box parts are all machined on the joints, and have accurately fitted turned pins.

Ladles used for casting straight pipes are of special design, having four self-skimming lips corresponding to four gates in the mould. For casting connections, the usual type of bowl ladle is used to convey the iron to that section, where it is transferred to hand shanks for pouring into the moulds.

Fettling Shop.

The cleaning department is equipped with dry grinders, pneumatic chipping hammers, and electric portable grinders; steel wire circular brushes are used for removing sand from inside the pipes, and tumbling barrels will shortly be installed. Dipping, when required, is done in tanks sunk into the ground. The pipes are conveyed by mono-rail to the tank, after passing through a pre-heating chamber, and are lowered and raised by motor. The mono-rail is endless, running through the stockyard of saleable castings, to the loading platform.

The whole of the works-layout is thoroughly systematic, the method of manufacture is highly efficient, and the resulting castings are produced in India of a very high standard. The labour employed is entirely native, under European supervision. During the British Empire Exhibition held in Calcutta during November, 1923, this firm were awarded, in the Indian Section, a Gold Medal for light castings.

The Eastern Light Castings Company, Limited, which is incorporated in Scotland, has its head office at 6 and 7, Clive Street, Calcutta. Messrs. Martin & Company are the managing agents.

A Farewell Banquet to Mr. H. Cole-Estep.

Last Thursday the friends of Mr. H. Cole-Estep took advantage of the presence at Birmingham Foundry Trades' Exhibition of representative foundrymen to offer him a farewell dinner and to present him with a souvenir of his stay in Europe. The organisation was in the hands of Messrs. H. Roe and W. O'Keefe. The chair was taken by Mr. F. J. Cook, who, in proposing the toast of Mr. Estep's health, said that the guest of the evening had been largely responsible for inaugurating the excellent system of international exchange papers, not only between the American Foundrymen's Association and the Institute of British Foundrymen, but also between most of the other national foundry technical societies.

Mr. Retallack, who supported, referred to the unlimited hospitality he had received from Mr. Estep's firm at Cleveland, and insisted that the international co-operation of business and technical interests between English-speaking peoples went a long way in the direction of mutual understanding, and so largely contributed to the peace of the world.

Mons. Ronceray, on behalf of the Association Technique de Fonderie, took advantage of the occasion to thank Mr. Estep for his contribution to the success of the International Foundry Congress, held in Paris last September.

Mr. Estep, in reply, said that he felt at home immediately on arrival in England. His reception had always been of the most cordial character. He referred at some length to his efforts to promote better international understanding by the exchange of papers. This had now grown to such an extent that no less than eighteen had been presented. He struck a note of warning, that unless enthusiasm was maintained on both sides of the Atlantic the arrangement might fall through. He intended on his part to do his utmost to keep alive this spirit. As a technical journalist he congratulated the British foundry trades on having in the FOUNDRY TRADE JOURNAL a real live journal to represent their interests. He took advantage of the occasion to thank his British foundry friends for the wonderful time they had given him during his sojourn in Europe, and especially thanked Messrs. Cook, Retallack and Ronceray for their expressions of appreciation.

Mr. Cook then presented to Mr. Estep a silver cigarette case and a silver cigarette box, both suitably inscribed, and said that he wished Mr. Estep to accept these, not for their intrinsic worth, but as a token of respect in which he was held by British foundrymen. Mr. Estep having suitably replied, the Chairman called upon Mr. V. C. Faulkner, who, on behalf of the London Branch, expressed appreciation of the work done by Mr. Estep on the various committees, especially the sub-committee which dealt with the reception of the American Foundrymen's Association last August.

Amongst those present, and in addition to those mentioned, were Messrs. Robt. Buchanon (past president of the Institute of British Foundrymen), I. Lester, J. G. Pearce (director British Cast-Iron Research Association), J. E. Fletcher, H. D. Wood, P. Jump and F. J. Barraball (London). Apologies were received from Mr. R. O. Patterson (President of the I.B.F.), and Mr. Oliver Stubbs (past-President).

A Comment upon the Methods of Judging and Mixing Pig-Iron.*

By H. J. Young, F.I.C.

Experience of the manufacture of non-ferrous metals teaches the value of control by composition; it demonstrates that, other things being equal, there is no other control. As a typical example may be taken the simple alloy of 60 parts of copper with 40 of zinc, called Muntz metal.

Twenty years ago a works making this alloy would possess a "fracture-diviner," which gentleman could tell, by looking at the fracture of small testbars cast under standard conditions, the amount of copper in the alloy. His judgment was used to warn the casters when to add more spelter, or the rollers when the metal was to be expected to be soft or hard.

His fellow-workmen believed in his judgment beyond any science. As a matter of fact, as was actually proved by experience, he was so unreliable that enormous sums of money were lost as the result of firms relying upon the fracture-diviner.

A chemist in contact with work of that nature was able to study the wonderful powers of this man, to learn where he failed, and to ascertain the large quantity of charlatanism intermingled with his skill. The fracture-diviner relied upon "patter" to carry him over the thinner ice.

Another lesson, obtained in non-ferrous work, is that of the extreme difficulty of making two testbars so alike that they will give precisely similar results. No foundryman can control all factors so that he can cast, at will, several testbars, say, of Admiralty gunmetal, 88 : 10 : 2, all of which will give identical results. His test-sheets, from day to day, show varying figures. Curious to relate, the copper and zinc merchants do not claim wonderful properties for their metals irrespective of the impurities contained therein—due, in all probability, to the fact that the non-ferrous worker, as a general rule, would not credit fairy tales similar to those served up to the iron-foundryman.

Pig-Iron Propaganda.

The latter, on the other hand, appears to take his job, so far as its metallurgy is concerned, more easily. In general he is a fatalist believing himself at the mercy of a metallurgical god concealed within the material. Let him pay homage in the right direction and all will be well, but let him buy the wrong brand and no science or knowledge can save him—such is his faith.

His state of mind has been formed partly by means of long and skilful propaganda existing today as pamphlets, books, papers, written cunningly in scientific-looking language. The authors of this class of document lie in wait for the legitimate scientists, and pounce upon and advertise the slightest thing he may say which can be used or twisted to the advantage of their doctrine. The sum and substance of their teaching is to make foundrymen believe that the properties of any one brand of pig-iron remain unchanged even when the impurities alter—that is the essence of the propaganda.

Where Fracture Test Fails.

The fracture of a pig of iron depends not only upon its composition, but, in addition, upon its shape, its mass, its position in relation to other adjoining pigs or sows, its situation in the pig bed, the temperature of the metal when it reaches the mould, the condition and nature of the mould and the rate and manner of cooling. To look at the fracture of a consignment of pig-iron and to tell, with accuracy, the difference between it and that of the consignment just used up is an act beyond human power.

A word may be said about "mixing by fracture." The writer has never seen this done. Usually, as the pig is being unloaded, the foreman gazes at the fracture and uses the same standard mixtures as he has employed for years past. Actually, the man wisely relies upon the composition of the iron being not far off what it was before; which hope is realised, in the majority of cases, to a degree sufficient for rule-of-thumb or important work.

Twelve or more years ago, the late Dr. J. E. Stead told the writer that if he could imitate synthetically, with one lot of pig-irons, the composition of iron, obtained from another lot, those two cast irons would be alike. *In the case of all ordinary pig-irons, that is true and has been proved, time after time, year in and year out, over all kinds of pig-iron, before, during, and since the war.*

The head of the French Munitions Department stated that his experience, over innumerable quantities of cast iron shells, proved that when the composition was alike the physical tests were similar, no matter whether the material was semi-steel or ordinary cast iron. The writer has had the same experience over large numbers of castings and using many different brands of pig-iron.

The average foundryman, including the one with a small laboratory at his command, has no idea of the difficult task it is to make two castings alike in composition from different pig-irons. There would appear to be very few foundries in the country where this is being attempted seriously. Probably there are few laboratories doing accurate "mass" analysis of cast iron and pig iron. The writer has no hesitation in saying that the graphitic and combined carbons are estimated accurately very seldom. Any chemist can prove this for himself by circulating half-a-dozen samples.

Control of Composition.

The foolish talk about the impossibility of control by composition is based upon lack of experience. A foundry with a couple of analysts is not controlling by composition. It may be controlling by silicon or sulphur or both; but not by carbon, silicon, phosphorus, sulphur and manganese, at one and the same time, before and after cupola melting.

The carbon-content alone is a great difficulty. Nothing else is more vital to cast iron, of any one composition, than a variation in its carbon-content, other things remaining the same. The carbon of the mixture must be accurately known and adjusted if there is to be proper control of the physical properties of the metal tapped. A thousand-and-one inherent properties of pig-iron can be *imagined* by reason of a very little slackness in this matter of carbon . . . . moreover, there is only one way of getting a grip upon it.

The literature of pig-iron is distinguished by pictures of fractures, approximate analyses, and a selection of the following terms italicised—hard, soft, fluid, tough, lively, open, of cylinder quality, close, prime, non-growing, tenacious, economical, good, non-porous, of mixing character, medium, scrap-carrying, sound, free from hair cracks, dense, machineable, non-shrinking, wear-resisting, tight.

In spite of all of which, it is a proved fact, freely admitted by the manufacturer or agent, that the iron delivered varies from time to time, and all the time, in carbon, silicon, phosphorus, sulphur and manganese.

The only way of efficient grading and mixing is by the medium of accurate and complete analysis; only by that method is it possible to standardise the quality of the castings and to maintain that quality when the pig-irons vary or are varied.

Irons containing rare elements or rare quantities of elements and, therefore, exhibiting exceptional properties, must be dealt with separately.

Much remains to be done on cast iron, but the most necessary and urgent act of all is to bring about the universal choosing and mixing of irons according to composition. The delay in this matter is a delay to progress.

* A Paper presented to a foundry Congress held in conjunction with the International Foundry Trades Exhibition at Birmingham.

MR. P. J. PYBUS, managing director of the English Electric Company, Limited, has just returned to London from his third business visit to Canada since the war.

VICE-CHANCELLOR LAWRENCE, at Lancashire Chancery Court, Manchester, has sanctioned the proposal to reduce the capital of Crossley Bros., Limited, from £2,000,000 to £1,492,293, by cancelling the capital which has been lost or is unrepresented by available assets.

THE BRITISH EMPIRE STEEL CORPORATION is stated to have entered into negotiations with Ruhr steel interests for supplies of Wabana iron ore over a prolonged period. A draft agreement covering the remainder of this year has already been made, but the German manufacturers are believed to be desirous of making plans for regular supplies. Mr. Roy M. Wolvin, President of the Corporation, has recently visited Germany in connection with this business.

Core Oil Values.

By an American Correspondent.

The base oils used in core oils are generally linseed, corn, soya bean, cottonseed, and similar oils. Additions may be rosin oil, raw rosin, pitch and gums blended and kept in solution by the addition of mineral, fuel, or neutral oils. Many blenders of core oils also use different fish oils in the manufacture. The question often arises as to the comparative values of the different compounded oils, and their adaptability to the work expected of them. No standard can be set as to the value of core oil used, as sand conditions, storage, handling, and class of work and metals have to be considered. The base oils used in the manufacture of core oils grade as follows in bonding value when used in their pure state: (1) Linseed oil; (2) corn oil; (3) soya-bean oil; (4) cottonseed oil; and (5) fish oils. Chemists grade these oils according to their iodine values, which means the measure of bonding values contained.

Relative Cost of Raw Materials.

The additional rosins, gums, and pitches also have bonding value to a much lesser extent and would rate about in the order given. Mineral, fuel and neutral oils have no bonding value to speak of, and are added to keep the blend in perfect solution and to cheapen the eventual mixture. It can readily be seen that core oils made by a reputable manufacturer are priced according to the value of their ingredients: the base oils, such as linseed, corn, etc., being high priced and subject to market fluctuations; rosins oils, gums and rosin follow next in price, mineral oil and its derivatives being the cheapest, prices ranging at present for base oils from 3s. 4d. to 4s. 2d. per gallon, rosin oil and prepared rosin from 7½d. to 1s. 8d. per gallon, mineral oils from 2½d. to 7½d. per gallon. Thus it may be assumed that the cheaper grades of compounded core oils are highly diluted with the cheaper ingredients and cannot be expected to have a high bonding value. If one calculated on the ratio of sand they can bind with better grades they would convince themselves readily and adopt the better grades, thereby eliminated the fluctuations in quality and the greatest enemy of the trade, the smoke nuisance. Rosin and rosin oils are added to help to speed up the drying of the cores, as the base oils in the pure state are slow driers.

Flash Point Testing.

In order to determine the quality of the core oils on hand, the tensile test has been a standard practice for a great many years, but unfortunately many foundries are not equipped for such tests and simply rely by feel and rubbing cores together to give them an idea of the binding strength of the core oil. A very simple test, giving the foundryman a check on every barrel bought, without first making up cores, would be the flash or burning test. Base oils and other ingredients vary greatly in the flash or burning point. Approximate figures are given in Table I:—

TABLE I.—*Flash Point Ranges of Core Oil Bases.*

Material.	Flash Point Range in Deg. C.
Linseed oil	250—260
Soya-bean oil	250—260
Corn oil	250—260
Cottonseed oil	235
Fish oils	235—245
Rosin and gums used	175—195
Mineral oil	80—105

It can readily be seen that in a mixture of linseed oil, rosin and mineral oil reaching a certain flash point, any change in its constitution will change the flash point, employing less linseed will lower, in fact, the percentage of linseed or any base oil with high flash point used regulates its flash point also its bonding value. That is why a cheap core oil, though more oil is used in the mix, may dry easily, but the cores will also scorch or burn more easily than an oil containing high percentage of base oils. Core oils of high flash-point allow one to raise temperature of ovens, giving a quick bake without the tendency to burn the cores, and as the flash-point has been increased by the greater percentage of base oils employed, it follows that the better binding ratio so much desired can be obtained. Summarised, high flash-point is a sign of: (1) High percentage of base oils; (2) high ratio of sand that can be used; (3) elimination of scorched cores; (4) quick baking owing to high temperatures that can be employed; (5) cleaner core boxes; (6) less handling of materials; (7) sharper edges on cores; (8) free venting cores; (9) less oil, therefore less smoke; and (10) easier cleaning of castings.

Details of Method Used.

A simple foundry test can be made by placing 2 in. of the core oil in a pint tin-can, such as is used for containing treacle. An inch-diameter hole is pierced in the centre of the lid and a second one near the edge, which should be barely large enough to take a 260-deg. C. thermometer. This is clamped to keep the bulb about ¼ in. from the bottom of the can. The whole is then heated by a Bunsen burner or other suitable means. When smoke and gases commence to issue from the central hole, a lighted taper is kept in contact with them until they light. At this time the thermometer reading is noted.

If using a satisfactory core oil, this method of testing will give a check on subsequent barrels by noting the flash-point of the satisfactory oil. A variation of 2 to 5 deg. C. will not seriously affect binding value, but as the flash-point increases or decreases it really indicates that the oil is higher or lower in base or high-binding oils, and therefore better or worse as the case may be. Base oils vary greatly as to the amount of so-called tear gas they generate when burning. Tests made show their offensiveness to increase in the following order: (1) corn oil; (2) soya-bean oil; (3) cottonseed oil; (4) fish oils; and (5) linseed oil.

Deductions to be Drawn.

From what has been said about flash-points, it does not necessarily follow that by decreasing the base oil and substituting, say, twice as much mineral oil, it would give a figure to conform with the flash-point of the different percentages involved. For example, using 50 per cent. base oil with a flash-point of 260 deg., 25 per cent. rosin (flash-point 120 deg.), and 25 per cent. mineral oil (flash-point 94 deg.), by calculation this should suit a mixture flashing at 210 deg. C., but in reality this will produce a mixture flashing much lower than figure given. The united gases coming from the heated mixture will flash, not according to the percentages involved, but according to the most easily liberated gases contained in the mixture, so that a mixture may contain 50 per cent. base oil of high flash-point, the other 50 per cent. low flash-point material. The gases arising may have only 10 to 15 per cent. of the base oil gases involved owing to the heat acting on the low flash-point materials more readily. Table II outlines the values and changes that take place. These are not core-oil mixes, but are only used to show the value of the flash test and giving the foundryman an idea of the contents of the oil he is employing.

TABLE II.—*Flash-points of Core Oils.*

	Base oils. Per cent.	Rosins, etc, Per cent.	Mineral oil. Per cent.	Flash point. Deg. C.
1	100			255
2	95	5		240
3	90	5	5	220
4	80	10	10	170
5	70	15	15	131
6	60	20	20	105
7	50	25	25	98

The flash-points given from actual tests are within 5 deg. C. of the correct figure. The following figures taken by making flash-points of the separate ingredients and figuring according to the percentage of material used in the different blends would give the following results: (1) 255; (2) 250; (3) 245; (4) 232; (5) 221; (6) 210; and (7) 200 deg. C.

This indicates that flash-point changes not according to percentages of ingredients, but upon the action of the heat in liberating the gases from the mixture. However, it can be stated that the higher the flash-point of compounded core oils, the greater its binding power, greater heat resistance enabling one to bake cores faster, and as high flash-point indicates greater percentage of base oil, it follows that a greater binding ratio can be obtained.

XUM

Institute of British Foundrymen.

LANCASHIRE BRANCH.

Discussion on Mr. S. E. Dawson's Paper on Non-Magnetic Cast Iron.*

THE CHAIRMAN (Mr. R. A. Miles) said they could all appreciate the trouble which Mr. Dawson had gone to in preparing this lecture. He was not, like most men, content with things as they were; he wanted them to be better, and with that object pushed his investigations to the furthest limits in order to learn all that was possible about the materials he used, and to put the knowledge so acquired to practical use. Other members had not the same opportunities. Mr. Dawson was fortunate in that he was in the service of an eminently scientific firm, who must appreciate his efforts to produce material suitable for a particular class of work and also less costly than that used by other firms for the same purpose.

MR. J. S. PRIMROSE hoped the author would amend his statement that all alloys of two metals contained a eutectic, and also that he would improve on the selection of pearlite as an example of a eutectic. Strictly speaking, it was not a eutectic at all, as it lacked the first characteristic that it must be formed from a liquid (and not a solid) solution. He sympathised with Mr. Dawson's comments on the indiscriminate fashion in which samples of pig or cast iron were taken for analysis. He quoted an instance which had happened during the war when he had been interested in the manufacture of some cast-iron "guns" for depth-charge throwing by the Navy. As the explosive force had to be directed round two right angles, the authorities had at first prescribed only 0.1 per cent. phosphorus in the iron, but finally agreed to accept 1.0 per cent. P. The mixing of the charge was under proper control, and ladle samples showed not more than 0.8 per cent. phosphorus. Although the 9.5-in. guns satisfactorily withstood the severe hydraulic test, they were all at first rejected on the ground that the analysis showed from 1.2 to 1.3 per cent. phosphorus. The reason for this was that the sample for analysis had been taken by the officials concerned from the centre of a 4-in. cube of the same metal which had to be cast with each gun and forwarded to the Sheffield test house. It was a considerable time before the proper method of sampling was adopted, and then all the castings were accepted.

The cooling curves of alloys were undoubtedly important for the information they gave; but the speaker considered the difference of temperature referred to by Mr. Dawson, *i.e.*, between the hot specimen and a neutral body, was really of no use for constructing a graph unless one also knew the actual temperatures at which these differences occurred.

Nickel in Cast Iron.

He had been specially interested in what Mr. Dawson had had to say on the effect of nickel on cast iron. At one time he had examined the effect of 18 per cent. of nickel on pig-iron and found it had precipitated nearly all the carbon in the form of very curly graphite, of which he had always been a strong advocate. When melted in a cupola charge to give about 6 per cent. of nickel in the resulting cast iron the graphite flakes were no longer curly, and the ground mass was composed of ferrite, in which the nickel as well as the 2.6 per cent. of silicon was dissolved, and surrounding this was an almost continuous meshwork of sorbitic pearlite. This made a very strong structure, and even the fins of metal were pliable when they came to be removed during the fettling operation.

This was no doubt a lower percentage of nickel than that used by Mr. Dawson, who aimed at the austenite-graphite structure, as shown by his photo-micrograph of Nomag metal (Fig. 8). Such a material might be called an alloy, but it certainly was not cast iron, for the first property of iron was that it was magnetic. The remarkable thing was that such material could be easily machined without annealing. It was also noteworthy that dipping this material into liquid air did not alter its structure and restore a state of magnetic constituents. He had found that certain manganese steels which, even when annealed, were perfectly hard—unmachinable in fact, and quite non-magnetic, with a martensite-austenite structure—had been rendered soft, perfectly magnetic, and largely sorbitic in structure by a short immersion in liquid air. This was a reversible transformation, but evidently the nickel used had been sufficient to render the iron alloy one with an irreversible constitution.

Vote of Thanks.

At the invitation of the Chairman, MR. FIELD, of the Birmingham Branch, addressed the meeting. He said he had not come as a delegate, but he was sure if his fellow-members had known that he was coming they would have sent their cordial greetings to the Lancashire Branch. He was particularly pleased that he had been asked by the Chairman to move a vote of thanks to Mr. Dawson for this Paper, which embodied a great deal of technical matter on a most difficult subject. Mr. Dawson had explained it lucidly, but he had not conveyed to the minds of the members an adequate conception of the amount of work which had to be done to obtain the results shown by him. Years of study and work must have preceded it; quite a number of experiments and failures must have led up to the discovery of the successful method the explanation of which had been given in a lecture of less than two hours' duration. In these days the requirements made on foundry firms were becoming more exacting. He had even known them to be asked to produce castings which would be magnetic under certain circumstances and non-magnetic under other circumstances. They were expected to do much more than their forefathers did. So he was glad to have had the opportunity of being present and hearing Mr. Dawson put before the members material which would have a great effect on a large part of the work of the ironfounder, not only in connection with the electrical industries, but also to a large extent in constructional work. He would be very glad if Mr. Dawson would give a similar lecture before the members of the Birmingham Branch.

MR. MASTERS, in seconding the vote of thanks, said quite recently the question of phosphide in iron was brought emphatically to his mind in connection with the casting of a hammer block. There was an oxidation on the plate of metal half an inch thick. The metal was quite stiff on the outside. He did not have it analysed, but from what Mr. Dawson had said he gathered that it was phosphide eutectic or phosphide of iron.

The vote of thanks was passed unanimously.

The Author's Reply.

In replying, MR. DAWSON said the addition of nickel to cast iron was being advocated for motor cylinders and other similar work when it was claimed that softness, together with closeness of grain and toughness, was obtained. The percentage added for this purpose varied between 1.0 and 3.0 per cent.

The effect of nickel on cast iron is similar to that of silicon (although probably not so strong) in that it precipitates the graphite, and also probably tends to reduce total carbon. For example, a cast iron with a total carbon of 3.89 per cent. showed 2.85 per cent. graphite with 0.87 per cent. nickel, 2.01 per cent. with 1.25 per cent. nickel, and 3.12 per cent. graphite with 5 per cent. nickel.*

Cobalt does not seem to have any effect on the carbon in this way. As regards magnetic effect, it acts in the opposite sense to nickel, and increases the permeability and hysterisis. Hence its use as an addition to magnet steels.

* See issue of May 29.

* Bauer.

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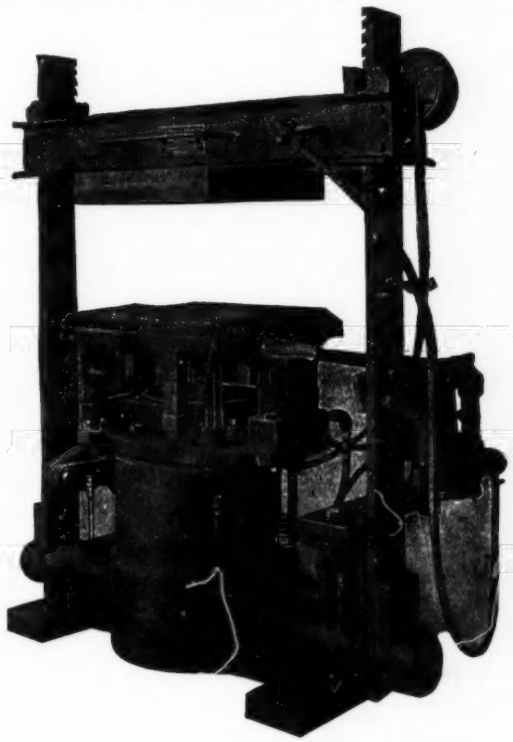

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Trade Talk.

RICHARD JOHNSON, CLAPHAM & MORRIS, LIMITED, have removed their Glasgow office to 128, Hope Street.

THE PARAMOUNT HOSIERY FORM COMPANY, LIMITED, are starting up in the near future an aluminium foundry at Beeston, Notts.

FERRANTI, LIMITED, have secured the contract for transformers for the electrical distribution system of the city of Cartagena, Colombia.

THE SHROPSHIRE IRON COMPANY, LIMITED, Hadley, near Wellington, Salop, have removed their London offices to 145, Cannon Street, E.C.

A LICENCE under the Non-Ferrous Metal Industry Act, 1918, has been granted by the Board of Trade to Mr. H. D. Goode, trading as Goode & Company, 11, Milk Street, Cheapside, London, E.C.2.

A FIRE which recently broke out in the works of the Falkirk Iron Company, Limited, Falkirk, caused considerable damage. The outbreak occurred in the enamelling shop, and spread to the oil store.

FULLER'S UNITED ELECTRIC WORKS, LIMITED, of Chadwell Heath, Essex, have established new Welsh depôts at the following addresses:—Swansea: Pier Street; Cardiff: 1, Wood Street; Newport, Mon.: 24, Dock Street.

MESSRS. LAWSON, WALTON & COMPANY, LIMITED, the well-known foundry equipment and supply firm, have gone into larger premises, which allows of a double-window display. The address, however, remains the same at St. Nicholas Buildings, Newcastle-on-Tyne.

THE MIDLAND MOTOR CYLINDER COMPANY, LIMITED, have opened a new foundry at Trafalgar Street, Coventry. The whole of the equipment except the cupolas has been supplied by the Pneulec Machine Company, of Mafeking Road, Smethwick.

THE new iron foundry at the Darnall Works of Davy Bros., Limited, which is equipped with ample crane power and labour-saving appliances, has just been completed at a cost of about £50,000, and is now in operation.

THE CUTLERS' COMPANY OF SHEFFIELD have been so far successful in their efforts to obtain registration for the word "Sheffield" under Section 62 of the Trade Marks Act of 1905 that they have been permitted to advertise the mark in the official Journal.

THE TOTAL Indian imports of cast-iron pipes and fittings during the year ending March 31 last fell from 27 to 15 lakhs (£185,625 to £103,125), those from the United Kingdom from 21 to 14 (£144,375 to £96,250), and those from other countries from 3 to 1½ lakhs (£20,625 to £10,312.5). The exchange has been taken at 1 rupee = 1s. 4½d.

IN OUR LAST ISSUE we stated that Mr. Gilbert Griffiths, the Birmingham and District representative of the General Refractories Company, Limited, of Kelham Island Firebrick Works, Sheffield, had changed his address from 39, Brandon Road, Hall Green, Birmingham, to 3, Fernley Road, Sparkhill, Birmingham. These two addresses should have been reversed, as Mr. Griffiths' new address is 39, Brandon Road, Hall Green, Birmingham.

THE ANNUAL REPORT of the Institution of Gas Engineers states that Dr. Charles Carpenter, having resigned his seat on the main committee of the Association as representative of the Institution of Civil Engineers, has also relinquished his position as representative of the Institution on the Association's Cast-Iron Pipes Committee. Mr. Albert Stokes has been appointed his successor on the latter. A contribution has been voted to the Association towards the cost of the initial experiments on sockets for cast-iron pipes for water, gas and sewage. Mr. Stephen Lacey has been appointed to represent the Institution on the Association's Sub-Committee on Screw Threads. With reference to the proposed standardisation of gas flanges, a sub-committee under the chairmanship of Mr. T. Hardie is preparing a report for the Sectional Committee on Pipe Flanges. Steps are being taken with a view to a definite recommendation being made on the matter. Conferences have been held with representatives of the Society of British Gas Industries as to the desirability of standardising plugs for gas taps, as a result of which an angle of taper of 7 deg., with a tolerance of 15 per cent. in either direction, has been unanimously agreed. In response to an invitation from the Institution of Civil Engineers, the council have appointed the following representatives to serve on the Heat Engine and Boiler Trials Tabulation Committee of that Institution: Messrs. William B. Booth, Walter Chaney, Stephen Lacey, and E. W. L. Nicol.

MR. ROBERT RONCERAY, son of Mons. Ronceray, the well-known French foundryman, is sailing for the United States on August 15.

Company News.

British Castings (Old Hill), Limited, Halesowen Road, Old Hill.—Capital £6,000 in £1 shares.

H. Beare & Sons, Limited, The Foundry, 26, Salisbury Road, Newton Abbot.—Capital £15,000 in £1 shares. Directors: T. L. Beare and H. L. Beare.

Burry Iron & Steel Company, Limited.—Capital £1,000. Directors: A. C. Jones and I. A. Watts. Solicitors: A. G. Brown, 4, Frederick Street, Llanelly.

F. Grazebrook & Company, Limited, Netherton Ironworks, Dudley.—Capital £1,000 in £1 shares. Iron and steel merchants, etc. Directors: O. F. Grazebrook and F. S. Wilkinson.

C. F. Wilson & Company, Limited, 166, Constitution Street, Leith.—Capital £10,000 in £1 shares. Engineers. Directors: A. Lightbody, A. Ross, C. B. M. Wilson and W. Lamb.

Peerless Weighing Machine Company (London), Limited, 13, Cambridge Place, London, W.—Capital £50,000. Directors: A. S. Rendall (chairman), W. A. M. Rolfe, E. S. Rendell and L. Spinks.

Joseph Jackson, Son & Company, Limited, 21, Britannia Street, London, N.1.—Capital £4,000. Engineers, founders, and contractors. Directors: J. Jackson (permanent chairman), Mrs. A. E. Jackson, A. R. Jackson and S. J. Morris.

Magnoid (Bristol), Limited, 42, Queen Anne Road, Barton Hill, Bristol.—Capital £1,000 in 600 10 per cent. cumulative preference and 400 ordinary shares of £1. Oxy-acetylene welders, electric welders, etc. Directors: T. H. Adkins, T. A. Vallender (both permanent) and A. Berkeley.

Contracts Open.

Rugby, July 14.—Providing and laying 3,124 yards of 4-in. and 3-in. cast-iron water mains, for the Rugby R.D.C. Mr. J. E. Weeks, surveyor, Hillmorton Paddox, Rugby. (Fee, £3 3s., returnable.)

Auckland, N.Z., July 10.—(1) A large jaw crusher, capable of dealing with 1½ cwt. spawls (columnar basalt) and reducing same to 5 in. and less at the rate of 250 cubic yards per day of eight hours; (2) two jaw crushers, each capable of reducing 125 cubic yards of 5-in. spawls to 2½ in. and less per day of eight hours; (3) one or two disc crushers capable of dealing with 120 cubic yards of 2-in. to 4-in. spawls and reducing same to ¾ in, and less per day of eight hours; (4) one belt-driven air compressor capable of supplying 200 cubic feet of free air (working pressure 100 lb. per sq. in.); and (5) five three-phase motors, 400 volts, 50 cycles, on adjustable rail beds, to drive the above. Room 40, New Zealand Government Office, 415, Strand, W.C.2.

Best Yorkshire Iron.

Subsidiary Concern to Handle Production.

Early last week an announcement was made to the trade by Robert Heath & Low Moor, Limited, Taylor Bros. & Company, Limited, and the Monk Bridge Iron & Steel Company, Limited, who are among the few remaining firms that make best Yorkshire iron, that they have decided in future to place the handling of this product with a subsidiary company that has been specially formed for the purpose.

The New Company.

The new company has been registered as the Best Yorkshire Iron, Limited, with registered offices at the Low Moor Ironworks, Bradford. The capital is £2,000, and the company has been formed to acquire the goodwill of the businesses of manufacturers of best Yorkshire iron carried on by Robert Heath & Low Moor, Limited, Taylor Brothers & Company, Limited, and the Monk Bridge Iron and Steel Company, Limited. The subscribers (each with one share) are: J. Bruce Harding, Kuypersley, Congleton, ironmaster; F. J. Kitson, Gledhow Grove, Chapel Allerton, Leeds, ironmaster. Secretary: G. H. Webb.

THE SEVENTY-SIXTH anniversary festival dinner in aid of the funds of the Royal Metal Trades' Pension and Benevolent Society will be held at the Cutlers' Hall, Warwick Lane, London, E.C.4, on Thursday, July 10. The chair will be taken by Sir Frederick Mills, Bart., J.P., chairman and managing director of the Ebbw Vale Steel, Iron and Coal Company, Limited, and the vice-chair by Mr. Robert William Kennard, J.P. (president of the Society), of the Falkirk Iron Company, Limited, and the Blaenavon Company, Limited. Tickets for the dinner may be obtained from Mr. W. Farmer, secretary, 195, Upper Thames Street, London, E.C.4.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Unfavourable conditions continue in evidence in the Cleveland iron market, holiday influences being responsible for some decline in home demand, while the export trade is also adversely affected by irregularities in the state of the various Continental exchanges. A certain amount of business is, however, passing, and consumers would, no doubt, be ready to do a good deal more, having regard to the present low prices, which certainly leave little, if any, margin for the ironmaster. But the fact is that the volume of trade in the home foundries and works is far from satisfactory, with the inevitable result that the demand for pig-iron is much below the average. Quotations continue weak and irregular. For the standard No. 3 G.M.B. quality, 88s. 6d. would appear to be a full figure. No. 1 is scarce, and could hardly be done at a premium of less than 5s. per ton on No. 3. There is plenty of No. 4 foundry on offer, and this quality is no more than 87s., while No. 4 forge is offered at 86s. per ton.

Conditions in the Tees-side hematite market are somewhat similar to those outlined above in ordinary pig, but there is a fair demand for iron of special analysis from France, although Italy is buying cheap French hematite. With the Italian lire at about 100, buyers are badly penalised in purchasing from England, and find it less onerous to cover their requirements in France. The quotation for East Coast mixed numbers is nominally held at 97s., but this figure could be readily shaded for suitable business. The No. 1 quality is at a premium of 6d. per ton. Business in the Cumberland and North Lancashire hematite trade continues to be of a humdrum character, with prices unchanged from last week's quotations.

LANCASHIRE.—The local demand for foundry pig is still considerably below the normal average for the season, and reports to hand appear to indicate a weaker tendency in prices for Midland qualities. There are some local merchants who claim that they have bought small lots of Derbyshire No. 3 at 100s. delivered Manchester, and this must mean that 92s. 6d. per ton at the furnaces has been accepted. It is true that selling agents do not quote below 93s. 6d., and some even keep to 94s., but it may be fairly stated that under pressure 1s. to 1s. 6d. per ton concession would be made. The Scottish pig-iron makers have at last recognised the fact that the market is weaker, and have put down the prices by about 2s. 6d. per ton, but this makes little difference in Manchester, because good brands of Scotch No. 3 were selling here at the lower price, and have been for some time.

THE MIDLANDS.—Buyers of foundry pig-iron in this area are still operating on a restricted scale, confined practically to hand-to-mouth transactions. With a very weak market and orders for castings not very plentiful, there is little forward buying at this juncture. The ruling prices are as follow:—Derbyshire No. 3 foundry, 92s. 6d. to 94s.; Staffordshire No. 3 foundry, 92s. 6d. to 94s.; Northants No. 3 foundry, 87s. 6d. to 90s.

SCOTLAND.—Business in the Scottish foundry pig markets remains dull and uneventful, although there has been a shade more buying of Cleveland iron on the part of the Falkirk consumers for delivery after the holidays. The prices at which these purchases have been made are 93s. 6d. for No. 3 and 91s. 6d. for No. 4 foundry, both per ton f.o.t. Grahamston. The price of No. 3 Scotch is nominally 97s. 6d. per ton at the furnaces, but there has been very little business passing in this grade.

Steel.

The outlook in the steel industry generally continues far from satisfactory, structural engineers especially complaining that they are being very inadequately supported, and such demand as there is runs in rather small quantities. Small bar makers are experiencing very keen home competition, while those producing in this district are finding themselves almost entirely cut out of the export trade by the lower prices which the coast firms are able to take owing to their having no land transport costs to pay. Continental prices for semi-products and sections have advanced, particularly the billet figure; £7 delivered Birmingham is asked, and is quite firm, as business at £6 17s. 6d. per ton has been turned down. There is no change in regard to bright drawn steel bars, the quotation being £15 10s. to £16 for basis sizes of rounds and squares. Delivery is usually effected from stock. Business in tinplates has been steady, the tone of the market is firm, and most works are now well booked up to August/September. Most of the business done was at the official minimum price of 22s. 9d. to 23s., net cash, f.o.b. Bristol Channel ports.

Scrap.

There has been no improvement to note in conditions in the scrap metal trade since last reported, and most markets continue dull and depressed. In Lancashire, inquiry all round is poor, and although it cannot be said that there is any definite reduction in the prices asked by the dealers, there is less inclination on their part to buy. Most of the Scottish consumers being idle on holiday account, business in scrap has been reduced to a minimum, with heavy machinery cast-iron scrap easier at 93s. 6d. to 95s. per ton, and ordinary quality suitable for foundries in pieces not exceeding one cwt. 3s. 6d. per ton less. Fairly good quantities have been sold at this figure. For heavy cast-iron scrap in furnace sizes suitable for steelworks 86s. to 87s. 6d. has been done. Old cast-iron railway chairs have also fallen in price, and some good parcels have been purchased under 95s. per ton, although foundries are not anxious to buy.

Metals.

Copper.—Movements in the standard market during the past week have reflected a steadier tendency, and at the close a slight improvement in values on balance was in evidence. The turnover for the week also indicated a fairly steady absorption on home consumption account, and it may be anticipated that the statistical position disclosed by the monthly figures will not be entirely unfavourable in a general sense. The demand from consumers on the other side of the Atlantic has remained generally of a hesitating and hand-to-mouth character, although there seems to be but little further room for a fall from the present level of prices. Current quotations:—*Cash*: Thursday, £60 12s. 6d.; Friday, £61 5s.; Monday, £61 15s.; Tuesday, £61 12s. 6d.; Wednesday, £61 5s. *Three Months*: Thursday, £61 10s.; Friday, £62 5s.; Monday, £62 15s.; Tuesday, £62 12s. 6d.; Wednesday, £62 2s. 6d.

Tin.—Values in the market for tin within the past week have evidenced a steady advance in quotations, due in a measure, doubtless, to a gradual return to confidence on the part of the majority of buyers on speculative account. Reports from America state that the demand from consumers has remained hesitating, partly owing to the circulation of pessimistic views through certain channels. America has shown her ability to remain out of the market longer than had been generally anticipated, and her attitude of indifference in a temporarily falling market may be persevered with as long as possible, although there seems to be ample room for new American purchases of Straits tin. Current quotations:—*Cash*: Thursday, £224 5s.; Friday, £224 12s. 6d.; Monday, £226 5s.; Tuesday, £228 10s.; Wednesday, £228 5s.. *Three Months*: Thursday, £224 7s. 6d.; Friday, £224 15s.; Monday, £226 10s.; Tuesday, £229 2s. 6d.; Wednesday, £228 10s.

Spelter.—Demand for this metal of late has taken a more active turn, the principal consuming industry absorbing fuller supplies than has been recently the case. According to recent advices the American stocks are heavier, and the full benefit of the Continental slowing down has thus not been received. Current quotations:—*Ordinary*: Thursday, £32; Friday, £32 5s.; Monday, £32 3s. 9d.; Tuesday, £32 2s. 6d.; Wednesday, £32 2s. 6d.

Lead.—The market for soft foreign pig continues steady, with values inclining to slightly lower levels. Naturally, the ease in values has been chiefly felt in the quotation for spot lead, and the backwardation has narrowed to some extent. There is little doubt that American lead will arrive here ere long, and, in consequence, we may still see a further contraction in the margin between spot and three months. Current quotations:—*Soft foreign (prompt)*: Thursday, £31 17s. 6d.; Friday, £32 2s. 6d.; Monday, £33 7s. 6d.; Tuesday, £32 15s.; Wednesday, £32 10s.

Institute of British Foundrymen.

Appointment of New Secretary for Newcastle.

At a recent meeting of the Newcastle Branch Council, Mr. Colin Gresty, of 93, Queen's Road, Monkseaton, was appointed Honorary Secretary of the Newcastle Branch in succession to Mr. H. A. J. Rang, who resigned the position a short while ago owing to pressure of other duties.

Mr. Gresty has been connected with the Institute for seven years, having served on the Branch Council for the last two years, and is also a delegate to the General Council.

Mr. Gresty acted as Secretary to the Newcastle Convention Committee, and his valuable work in that capacity was greatly appreciated. Therefore the Newcastle Branch can be congratulated upon the choice of its new secretary. This Branch has progressed very greatly under the secretaryship of Mr. Rang, the duties involved demanding the abilities of a very able man, and we feel sure that Mr. Gresty will prove a worthy successor.